

SN. OF HERPETOLOGY

UNIVERSITY
OF MICHIGAN

1959, No. 4

JAN 21 1960

December 30

Museum

MUSEUMS
LIBRARY

QZ

640

C78

Copeia

ESTABLISHED IN 1913

PUBLISHED BY

THE AMERICAN SOCIETY OF
ICHTHYOLOGISTS AND HERPETOLOGISTS

CONTENTS

JAW STRUCTURE AND TOOTH REPLACEMENT IN THE OPALEYE, <i>Girella nigricans</i> (AYRES) WITH NOTES ON OTHER SPECIES. By Kenneth S. Norris and John H. Prescott.....	275
<i>Lestidium johnfitchi</i> , A NEW BATHYPELAGIC FISH OF THE FAMILY PARALEPIDIDAE FROM OFF CALIFORNIA. By Robert R. Rosen.....	284
A NEW SPECIES OF <i>Labrisomus</i> FROM THE CARIBBEAN SEA, WITH NOTES ON OTHER FISHES OF THE SUBTRIBE LABRISOMINI. By Victor G. Springer.....	289
A NEW EEL OF THE GENUS <i>Kaupichthys</i> . By Kiyomatsu Matsubara and Hirotoishi Asano.....	293
DIET OF THE MISSISSIPPI THREADFIN SHAD, <i>Dorosoma petenense atchafalaya</i> , IN ARIZONA. By William L. Haskell.....	298
DISTRIBUTION AND VARIATION IN THE GLOSSY WATER SNAKE, <i>Natrix rigida</i> (SAY). By James E. Huheey.....	303
INTERNAL PIGMENTATION AND ULTRAVIOLET TRANSMISSION OF THE INTEGUMENT IN AMPHIBIANS AND REPTILES. By Don Hunsaker II and Clifford Johnson.....	311
THE ECOLOGY OF A BRACKISH WATER POPULATION OF <i>Rana pipiens</i> . By Rodolfo Ruibal.....	315
EFFECT OF TEMPERATURE ON CALL OF THE FROG, <i>Bombina variegata</i> . By Richard G. Zweifel.....	322
GENETIC INCOMPATIBILITY IN THE CALL RACES OF <i>Hyla versicolor</i> LeCONTE IN TEXAS. By Clifford Johnson.....	327
HERPETOLOGICAL NOTES	
<i>Lacerta</i> colony still extant at Philadelphia. By Roger Conant.....	335
Observations on the feeding behavior of a captive rosy boa, <i>Lichanura roseofusca</i> . By Don R. Medina.....	336
Longevity of snakes in the United States as of January 1, 1959. By Charles E. Shaw.....	336
Notes on the pH of the digestive tract of <i>Chrysemys picta</i> . By Sister Alice Marie Fox, B. V. M. and X. J. Musacchia.....	337
Observations on the nesting habits of the mudpuppy, <i>Necturus maculosus Rafinesque</i> . By Kenneth L. Fitch.....	339
A synonym and a homonym in the frog genus <i>Hyla</i> . By Coleman J. Goin.....	340
Response of a female <i>Pseudacris nigrita triseriata</i> to the call of a male. By Arthur N. Bragg.....	341
ICHTHYOLOGICAL NOTES	
Occurrence of three species of fishes in interstices of gravel in an area of subsurface flow. By J. L. Stegman and W. L. Minkley.....	341
Recent changes and corrections for the Minnesota fish fauna. By Samuel Eddy and James C. Underhill.....	342
Records of three marine fishes new to South Carolina. By C. E. Dawson.....	343
Extreme loss in body weight of an American shad (<i>Alosa sapidissima</i>). By Paul R. Nichols.....	343
The snake-eel, <i>Ophichthys cruentifer</i> , in Canadian Atlantic waters. By W. B. Scott and E. J. Crossman.....	344
Fecundity of the Arctic char, <i>Salvelinus alpinus</i> , of the Wood River Lakes, Bristol Bay, Alaska. By Richard B. Thompson.....	345
<i>Istiompax indicus</i> (Cuvier) 1831, a prior name for the black marlin. By James E. Morrow, Jr.....	347
Reviews and Comments.....	350
Editorial Notes and News.....	352
Summary of 1959 Meeting.....	355

FUTURE MEETINGS: Chicago Natural History Museum, Chicago, Illinois, June 17-19, 1960; The University of Texas, Austin, Texas, March 31-April 2, 1961; U. S. National Museum, Washington, D. C., June, 1962.

Jaw Structure and Tooth Replacement in the Opaleye, *Girella nigricans* (Ayres) with Notes on Other Species*

KENNETH S. NORRIS† AND JOHN H. PRESCOTT

DURING ecologic and systematic studies on the percoid fish family Girellidae it became evident that the species *Girella nigricans* possesses jaw and tooth anatomy somewhat different from that known for any other teleost. A superficial view of the intact jaws of this species reveals that anterior premaxillary and dentary teeth form several diagonal rows extending lateroventrally away from the median symphyses of the jaws. In large specimens thirty or more teeth may be exposed on a single ramus of one jaw bone. These teeth are rather loosely attached and usually some appear to be in the process of being shed.

The diagonal rows of teeth were found to continue beneath the tissue covering the anterior borders of the jaws. Dissection of the jaws and removal of the exposed and buried teeth revealed that none of these teeth are firmly attached to the jaw. The first row of functional teeth at the alveolar margin is loosely anchored between thin flanges of bone which project anteriorly from the jaw bones. The remaining teeth are buried in the surrounding tissue or project variable distances above it. Collectively, we call these teeth *primary teeth*. The tooth-containing tissue mass was found to occupy troughs along the anterior borders of the premaxillary and dentary bones (Fig. 1). The farther a tooth was from the functional row the less developed it was found to be. This initial examination aroused the suspicion that tooth primordia developed within the anterior trough tissue. This tissue, containing the developing teeth, seemed to move across the trough and finally the fully developed teeth became lodged between the flanges along the alveolar margin of the jaws, later to be shed and replaced. Such a mode of replacement, with teeth developing in an anterior position and moving posteriorly is the complete reverse of that known for elasmobranchs and hence was considered worthy of more detailed investigation.

Our attempt has been to define the functional anatomy of jaw structure and to outline the sequence and the timing of events involved in tooth development and replacement. We wished also to correlate the structures and events we found with the known habits of the species *Girella nigricans*. Finally, we wished to know if other fishes that are either close relatives or the ecological equivalents of *G. nigricans* possessed similar structures.

A considerable literature exists on the subject of fish teeth (see, for example, Owen, 1840-1845; Tomes, 1914; Levi, 1939; James, 1953; Luhman, 1954). The arrangement of teeth in sharks is well-known. Shark teeth have no direct connection with the cartilaginous jaws but are imbedded solely in the tough fibrous membrane that covers the jaws. Newly formed shark's teeth appear to originate within the mouth cavity in the posterior row, while the older functional teeth occupy the alveolar margins. This condition led Owen (1866) to state that "the whole phalanx of their numerous teeth is ever marching slowly forward in rotary progress over the alveolar border of the jaw, the teeth being successively cast off as they reach the outer margin and new teeth arising from the mucous membrane behind the rear of the phalanx." Cawston, in a series of papers (see Ifft and Zinn 1948, for references) challenged Owen's hypothesis, stating that he doubted that sharks shed their teeth and denying the possibility of replacement occurring by the forward movement from the rear. Ifft and Zinn (1948) produced experimental evidence in support of Owen's theory. They removed a series of teeth from the jaw of the smooth Dogfish, *Mustelus canis*. After removal of the teeth from a small section of the jaw, those remaining immediately posterior were marked. Later these teeth were observed to have migrated anteriorly to occupy the space left by the missing teeth. James (1953) gave a detailed analysis of the mode of replacement of shark teeth. He explained the succession of tooth rows on the basis of pressure developed by proliferation of the dental epi-

* Contribution Number 8, Marineland of the Pacific Biological Laboratory.

† The senior author's studies of the Opaleye, *Girella nigricans*, are being performed under National Science Foundation Grant G-1935. He wishes to express his appreciation for this support.

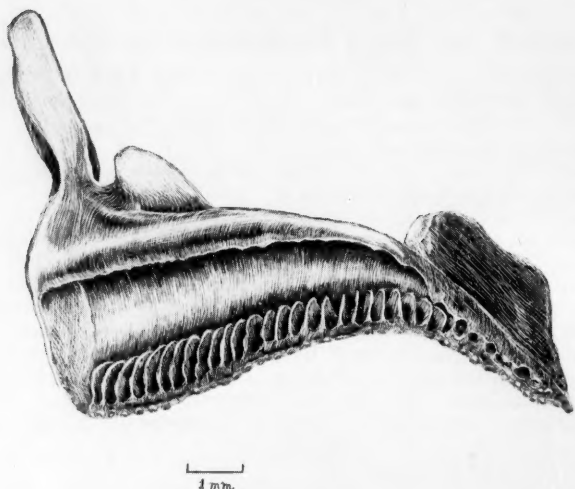


Fig. 1.—The left premaxilla of a 243 mm. (standard length)-adult *Girella nigricans*, from San Clemente Island, California.

thelium and intercellular tissue fluid tension, plus angular movement caused by connective tissue anchoring.

Most tooth replacement information for teleosts involves teeth that have their origin below the existing teeth. However, Owen (1840–1845) briefly described the dentition of some fishes that seemingly have replacement mechanisms similar to that of *Girella nigricans*. Of the maxillary teeth of the blenny, "*Salarias*," he says: "[these teeth] are extremely thin and slender, and are hooked at the extremity; but they are chiefly remarkable in being attached, like the teeth of the Squaloids, to the gum only, or membrane covering the intermaxillary and premandibular bones, so that they readily yield to pressure; there are about two hundred of these teeth in each jaw." This condition may be identical to that we discuss later in this paper for the blenny, *Ophioblennius steindachneri*. Owen also mentions tooth arrangements in *Zeus faber*, in *Scarus* sp., in the Chaetodontidae, in *Pimelipterus*, in *Chrysophrys*, and in the neotropical catfishes (classed as Goniodonts by Owen) that may be related to the condition we describe here. Two recent authors have described serial replacement of teeth in teleosts quite similar to that reported here for *Girella nigricans*. Eaton (1935) re-

ports that in the loricariid, *Plecostomus cordovae*, there exists a series of needle-like teeth projecting from each jaw, outside the oral cavity. He says, "The entire series of teeth in each dentary and premaxilla lies in a deep trough in the bone, . . . and those toward the exterior grow progressively more complete and more angular until the last and oldest in the series emerges ready for use. Doubtless this one breaks off easily, to be replaced at once by the next one below." Ebeling (1957) presents evidence that in the Pacific mullets, *Chaenomugil*, *Mugil*, and *Xenomugil* serial replacement teeth are present. Replacement teeth arise outside the mouth cavity on the anterior border of the jaw, and presumably rotate posteriorly to replace their functional predecessors. In the case of *Plecostomus*, tooth primordia arise in depressions on the anterior face of the jaw bones. The teeth of the mullets arise within the tissue of the lips and not in a bony trough. There are many facets of tooth development and replacement in these fish that remain unknown and also many details which obviously differ from the condition in *Girella nigricans*.

To evaluate the apparent replacement cycle in the Opaleye a series of jaws was prepared and examined. This series included

Girella
juveni
and pr
entire
ease
found
structu
study
for a v
teeth.
stiff ca
were
dissect
tional

Gro
and d
of two
dian
(Fig.
simila
sal su
small
rigidly
transv
trough
the m
slight
nate
anter
curve
with
prote
dia a
surfa
insid
smoo
trough
ject a
cated
trough
vidua
medi
trough
artic
tinua
near
ward
fill t

Ju
the
ing t
of p
teeth
poro
upor

1 A
growt
larval

Girella from a 21 mm. (standard length)-prejuvenile¹ to a 309 mm.-adult fish. Both fresh and preserved specimens were examined. The entire jaw structure was generally excised for ease of examination. Fresh specimens were found to be best suited for study of the bone structure and tissue attachments. For the study of bone structure the jaws were boiled for a very short time to loosen the tissue and teeth. The tissue was then removed with a stiff camel's hair brush. Preserved specimens were imbedded in histological paraffin and dissected by hand. Both frontal and cross-sectional dissections were made.

Gross jaw structure.—Each premaxillary and dentary of *Girella nigricans* is composed of two major portions, the transverse or median portion and the shorter lateral ramus (Fig. 1). The structure of the lateral ramus is similar to that of many bony fishes. Its dorsal surfaces are of porous bone upon which small spade-like teeth rest, each anchored rigidly to a rounded bony prominence. The transverse portion has a deep, open anterior trough along its face, which ends abruptly at the median symphysis. These troughs taper slightly toward the lateral ends and terminate at the flexure of the lateral ramus. The anterior lip of the transverse trough is recurved slightly, to a degree that increases with the size of the fish. This lip affords a protective shield covering the tooth primordia and their surrounding tissue mass. The surfaces of the bottom of the trough and the inside of the anterior bony lip are relatively smooth. The posterior or alveolar wall of the trough has many flanges of bone which project anteriad, creating a system of grooves located at right angles to the major axis of the trough. It is in these grooves that the individual functional primary teeth anchor. Bony median symphyses block the horizontal troughs where the premaxillaries or dentaries articulate, and create separations in the continuous rows of teeth. The flanges of bone near the symphyses slant at a slight angle toward them and direct the teeth medially to fill the spaces over the symphyses.

Just posterior to the alveolar border within the mouth cavity is a band of smaller scraping teeth slightly separated from the first row of primary teeth. The bone beneath these teeth is much like that of the lateral rami, porous and bearing small bony pedestals upon which the teeth are firmly anchored.

These teeth, like those of the lateral rami, are replaced directly from below.

Primary tooth structure.—Each functional primary tooth is composed of a basal supporting segment, and a distal scraping segment (Fig. 2). The hard distal segment is a hollow columnar shaft topped by a hoe-shaped scraping blade. The scraping blade in the species *Girella nigricans* is generally, though not always, tricuspid. At the base of the hollow shaft is an articulating joint that connects with the articulating surface of the basal segment. It is of the type called a *hinge joint*, and is found in a variety of animals. It is always associated with reduction in rotational or lateral movements of the members concerned. For example such a joint is present in the digging toes of anteaters (*Myrmecophaga*), which must resist rotational movements to be effective digging tools.

There is a slight groove along the posterior face of the hollow shaft in which a connective tissue mass inserts. This groove extends from a point below the scraping blade flexure almost to the articulating joint.

The basal segment is a flattened blade-shaped bone about twice as long as wide, which fits between the bony flanges of the jaw bone, serving to anchor the functional tooth, and ends distally in an articulating surface. The bottom of the basal segment terminates in a U-shaped end that rests over a soft bony projection of the jaw bone at the base of each flange.

Tooth development.—New teeth appear to arise in the tissue mass just beneath the anterior trough border (Fig. 3). The tooth buds apparently arise within individual capsules or "enamel organs." There seems to be no discernible tooth band such as is found in elasmobranchs (see Tomes, 1914:150). When initially distinguishable under a dissecting scope, the tricuspid scraping blade is already fully developed to its final size. It is the first structure that is discernible and is seemingly laid down entire. At this stage the blade is not hard but a thin pliable whitish tissue lying within the capsule. The shaft is absent at first but soon appears as an elongation from the base of the scraping blade. The scraping blade hardens as the shaft grows. This hardening begins at the cusps and progresses toward the shaft. When this progressive hardening reaches the base of the hoe-shaped blade, the shaft and blade flex at nearly 90 degrees. Then the basal segment begins to appear and tooth development is nearing completion. The hinge joint is then

¹ A term proposed by Hubbs (1958) for the distinctive growth stage that occurs in some fishes, between the post-larval form and the juvenile.



Fig. 2.—A fully developed functional primary tooth from a 243 mm. (standard length)-adult *Girella nigricans*. Note the well-developed hinge joint between the basal and distal segments.

formed and the hardening of the distal segment completed. The basal segment is not completely formed until the tooth is positioned between the flanges. During development, the teeth and presumably the surrounding tissue masses, move from beneath the anterior trough border, rotating downward, across the bottom of the trough, and upward toward the alveolar border of the jaw. This movement probably comes from a proliferation of dental epithelial tissue in the region of the anterior trough border, growing downward into the trough and causing a rotational movement of the entire tissue mass bearing the tooth primordia. Once these tooth primordia become attached at the posterior base of the trough, beneath the flange system, this same rotational movement of the surrounding tissues would serve to move them into place between the flanges. If this mechanism is correct, it is remarkably like that of elasmobranchs described by James (1953). Prior to completion of development the teeth begin to emerge above the tissue beneath the lips. First the scraping blade and gradually more of the distal shaft appears. As these teeth move toward the alveolar border other teeth appear below them.

The total number of visible teeth varies with the size of the fish. Small individuals (approximately 30 mm. standard length) have a single row in each ramus with an occasional replacement tooth appearing above the surrounding tissue totalling 7 to 10 teeth while adults (above 250 mm. standard length) have



Fig. 3.—Semi-diagrammatic cross section of the right premaxilla of a 243 mm. (standard length)-adult *Girella nigricans*. Note the developing tooth primordia within the bony trough.

three or four diagonal rows totalling between 20–30 teeth.

Tooth attachment.—During development the only connection of the teeth to the jaw is through the surrounding tissue mass. The tissue mass is not firmly attached to the bottom of the trough but is held in place by the overlying tissues. The tissue mass containing tooth primordia is continuous with the connective tissue of the lips and with the tissues above the flange system. The tissues surrounding the developing teeth appear to be intimately involved in the anchoring of the mature tooth. When the tooth is in the primary functional row the tissues surrounding it appear to be those that also differentiate to form the posterior connective tissue attachment and the thin sheath which encloses the basal segment of the tooth. This sheath is attached securely along the posterior margin of the basal segment. When in final position the basal segment rests on a tiny projection of porous bone. This bony rest is a projection that is easily separated from the denser bone of the jaw and may be eroded and re-deposited with each replacement.

The suspensory tissue of the distal segment attaches by anastomosis into the surrounding tissue of the alveolar border, in particular to a cartilage-like extension of the jaw bone above the tops of the flanges. Also it connects to the top of the basal segment on its posterior articulating surface.

Shedding of teeth.—During examination of living fish some of the primary teeth in each jaw of nearly every fish were found to be loose and apparently in the process of being shed. These teeth were no longer complete but had been partially eroded. The basal segment and the basal portion of the distal segment, including much of the joint, had undergone extensive erosion along their posterior margins. Presumably osteoclasts are present during shedding and resorb portions of the teeth.

EXPERIMENTAL STUDIES

The anatomical details that have just been discussed gave every indication that tooth replacement in the species *Girella nigricans* is a continuous process in which tooth buds arise, develop and move into functional position and then are shed. While such progressive serial replacement has been demonstrated for elasmobranchs, no such evidence exists for teleost teeth. Because of this we felt that it was desirable to test this replacement experimentally.

TABLE 1
SUMMARY OF ANAESTHESIA OF SIX ADULTS OF
*GIRELLA NIGRICANS**

Drug	Frequency of application	Dosage
TAA	17 times	4.5–5.0 cc/gallon
MS-222	5 times	2.3 grams/gallon
Methyl pentynol	4 times	3.5 cc/gallon

* Fish ranged from 297 to 332 mm. standard length. Anaesthesia covered a period from December 17, 1957, to May 26, 1958, or about one instance of anaesthesia per week.

Methods.—Individual teeth were marked by clipping the cusps from the scraping blade. Observations of clipped and non-clipped teeth on the same jaw revealed that abnormalities of replacement did not appear to result from the marking. It was necessary to anaesthetize the test fish to facilitate handling. Three drugs were used for anaesthesia: tricaine methanesulfonate (MS-222), methyl pentynol, and tertiary amyl alcohol (TAA). A summary of drug dosage and frequency of application is shown in Table 1. The anaesthetizing compound was dissolved in the sea water of a holding tank and the fish introduced. Anaesthesia was produced within 10 to 12 minutes with TAA. The operative state was defined as: no reaction to handling, fish inactive and its position inverted in the tank, and its opercular rate reduced and amplitude increased. When in this condition the fish was removed from the water and placed upon a table covered with a wet towel. The experimental opaleye were successfully kept out of water for periods of up to five minutes and not allowed to dry. After the cusps were clipped, the fish were returned to a tank of fresh sea water to revive. The time required for complete revival was slightly longer than the anaesthetizing period. Examination of the clipped teeth was accomplished by re-anaesthetizing the fish and making counts of the position of both clipped and unclipped teeth.

Cusp clipping was rapid and simple. A small pair of manicure clippers was used. The clipped blades were easily distinguished from intact teeth. Three combinations of individually clipped teeth or entire clipped rows or rami were used. The results with adult *Girella nigricans* are summarized in the following paragraphs.

(1) *A single tooth clipped just appearing above tissue mass near the median symphysis* (Experimental animal, 279 mm. standard

length).—The clipped tooth was observed to progress from the third row to the alveolar margin. On the 17th day after clipping the tooth shaft and the eroded basal segment were shed from the primary functional row.

Time (Days)	Position of tooth
0	Third series, only scraping blade above tissue
4	Second series, scraping blade and part of shaft exposed
8	In primary functional series
17	Shed from primary functional series with basal segment extensively eroded

(2) *A diagonal row of four teeth clipped* (Experimental animal, 309 mm. SL).—The clipped row extended from the median symphysis, with a tooth in the primary functional position, obliquely downward toward the lateral end of the horizontal trough where teeth were in the third row.

Time (Days)	Position of teeth
0	Four clipped teeth, extending from primary position to third row
4	Three clipped teeth, gap in primary row where tooth had been shed. Other teeth as before
8	Two clipped teeth, one in primary and one in second row
18	One clipped tooth in primary functional row
22	Last clipped tooth being shed with basal segment eroded

The progress of replacement in this experiment showed that the migration of entire rows of teeth is relatively uniform, like a wave washing diagonally onto the beach.

(3) *All visible teeth in right ramus of lower jaw clipped* (4 adult fish, 298 mm. to 332 mm.).—New unclipped teeth appeared in regular succession through the tissue beneath the lip, and these teeth moved into the primary functional row and were shed. This shedding did not appear to be preferential for clipped teeth since normal teeth were seen to loosen and fall out of the unclipped portion of the jaw periodically during the progress of the experiment. These normal teeth loosened in the same manner as the clipped teeth, and except for the lack of cusps in the experimental group they could not be visibly distinguished.

The time required to replace all the clipped teeth in a ramus varied from 22 to 32 days. During this period, between 21 and

28 teeth were successively shed and replaced (Fig. 4).

COMPARISONS

The jaw and tooth structure of several additional species of fishes closely related to *Girella* or that had similar habits were examined. In two species (*Microspathodon bairdi* and *Ophioblennius steindachneri*) a remarkable degree of structural convergence with *Girella* was found to exist. Both forms also are grazing vegetarians like *Girella*.

The pomacentrid, *Microspathodon bairdi*, has several longitudinal bands of teeth across the anterior transverse portion of its jaws. As in *Girella* these teeth are movable and hoe-shaped. The premaxillaries and dentaries have anterior troughs and a flange-groove system nearly identical with those of *Girella nigricans*. The teeth, however, are slightly different in structure. The basal portion of each tooth is anchored firmly between the flanges of the jawbone and resists movement. There is no joint developed between the basal and distal portions. The tooth graduates from flexible basal and medial portions to a hard dentine distal end. The shaft is narrow and somewhat flexible, rather than relatively rigid, as in *Girella*. The distal scraping blade is similar to that of *Girella* except that it is not tricuspid but a single flattened blade. The slim tooth-shaft is flexible enough to permit a movement of the tooth about equal to that permitted by the joint found in teeth of *G. nigricans*.

The blennioid, *Ophioblennius steindachneri* possesses serial tooth replacement much like that of *Girella nigricans* and *Microspathodon bairdi*. The anterior troughs of the premaxillaries and dentaries are present as are the diagonal serial rows of replacement teeth. These replacement teeth are completely buried in the tissue mass and have their genesis just under the anterior lip of the troughs, as is the condition in *Girella*. The individual teeth are without a median joint and are composed of a thin broadly-flattened basal portion topped by a narrow posteriorly-directed cusp. There is no thin flexible shaft, as in *Microspathodon*. The movability of the individual teeth, which is present in both *Girella* and *Microspathodon*, is produced by a mechanism different than that present in either form. The flange-groove system is absent and each flattened tooth in the primary row becomes connected to a flexible cartilaginous sheet attached to the alveolar border of the jaw. The result is that

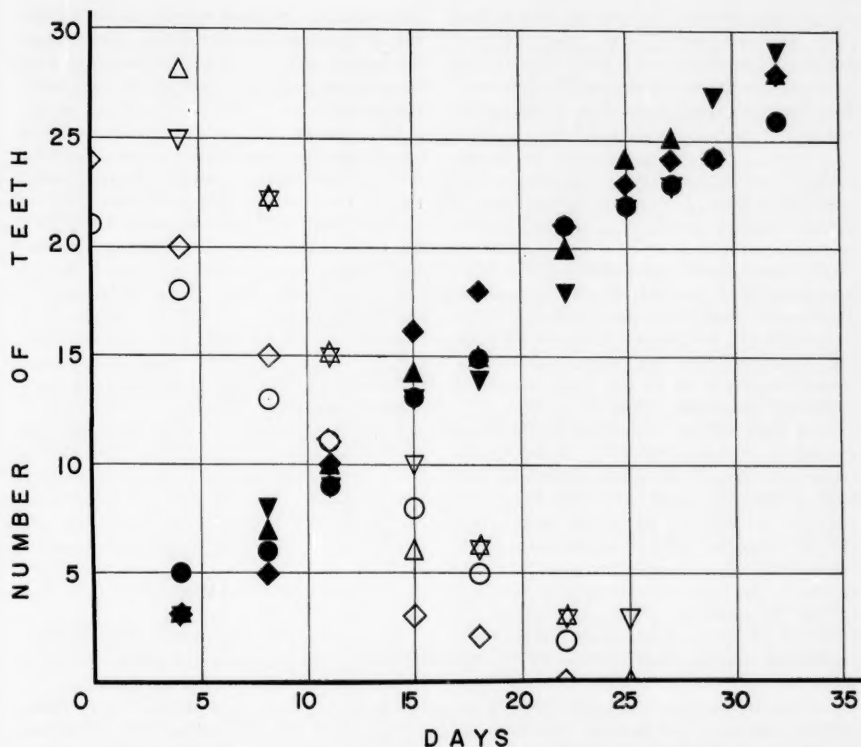


Fig. 4.—Tooth replacement rate in *Girella nigricans*. All exposed teeth on lower right ramus clipped in four adult fish. Solid symbols indicate numbers of replacement teeth in individual fish. Hollow symbols indicate numbers of clipped teeth in the same fish. Standard lengths are: triangle, 332 mm.; square, 310 mm.; circle, 299 mm.; inverted triangle, 298 mm.

adjacent teeth are not freely individually movable and movement of one tooth will create graduated parallel movements in the adjacent teeth.

The teeth are very numerous and laid diagonally inward toward the median symphysis.

Another blennioid, the rockpool blenny, *Hypsoblennius gilberti*, was examined. The feeding habits of this form are omnivorous (Barnhart, 1936). The primary functional teeth of this species are quite firmly fixed in a single row. Each tooth is laterally compressed and its distal dentine portion is topped by a single scraping or clipping blade. The wide base of each tooth is bony and anchored to the jaw. The basal portions of individual teeth are laterally joined by bone to neighboring teeth.

Like the grazing species just discussed,

Hypsoblennius has an anterior trough system. However the anterior lip of bone is recurved, forming an almost complete roof over the trough cavity. Replacement teeth project above the roof through small holes. Where a second-row tooth is actively replacing a primary functional tooth, the bony base of the primary tooth was found to be in the process of erosion.

Some authors (see for example Jordan and Thompson, 1912) have considered the families Girellidae and Kyphosidae as one. Therefore it was decided to make an inspection of a typical kyphosid to determine if structural similarities exist between the jaw and tooth structures within these two families. In the kyphosid, the zebraperch, *Hermosilla azurea*, the single primary tooth row consists of incisoriform teeth that interdigitate with the teeth of the opposite jaw. These teeth form

an efficient clipping mechanism that is basically different from the scraping organ of *Girella*. The primary teeth have a broad bony base and are firmly attached to the jaw bone. Replacement appears to take place in the anterior-to-posterior direction from the front of a trough as in *Girella*. However, the trough is almost completely roofed over with a thin covering of bone. The tips of tooth primordia project through this bony cover and appear to erode away the bone in the path of movement toward functional position, while bone growth fills in behind the moving tooth. Within the trough the serial rows of tooth primordia are diagonally arranged in pockets. Two rows of replacement teeth were found to project above the tissue surface in a 73-mm. specimen.

The bony trough cover appears to be an extension of the anterior lip of the trough of the jaw bone. If the roof is forced upward with a dissecting needle the weak bony connections between the projecting teeth break free and reveal a series of replacement teeth. These teeth are arranged in diagonal series in much the same manner as *Girella*. Each of the primordia, however, is nearly surrounded by bone. Replacement of primary functional teeth appears to occur by a movement of new teeth toward the alveolar border and a resorption of the bony base of the primary teeth. As the bony base is built up under the replacement tooth, the old tooth is gradually undermined and finally cast off. Thus the condition in *Hermosilla* is strikingly similar to that of *Hypsoblennius*, while having only a moderate similarity to that of *Girella*.

DISCUSSION

Since the jaw structure and tooth replacement found in *Girella nigricans* has been found to be widespread among teleosts, and since further examination of other grazing fish will almost certainly uncover other examples, we feel that a general descriptive term for this replacement type would be of value. We propose *progenic serial replacement* as descriptive of the condition in the forms described here. This term is intended to include forms with serial formation of tooth primordia within a trough or groove, or within anterior lip tissue, on the anterior face of the premaxillaries and dentaries, with subsequent posterior rotational movement into functional position during growth. The term polyphyodont is often used to describe

teeth that are replaced repeatedly during the life of the organism (see Eaton, 1951:91). If this term is used, the condition described here would then be called *progenic polyphyodont replacement*.

The jaw and tooth structures outlined here for *Girella nigricans* appear to be a complex structural adaptation to a grazing or scraping type of food-getting. The structures combine to allow individual teeth to move closely over the inequalities of rock surfaces as the animal scrapes loose encrusting algal scums or fine filamentous algae. This flexibility has been achieved in three different ways in fishes examined by us. In *Girella* the jointed teeth and posterior connective tissue attachment, combined with the lack of surrounding bone allow considerable individual anterior-posterior tooth movement. In *Ophioblennius* the teeth attach to a cartilagenous sheet arising from the alveolar border of the jaw. The extremely numerous teeth and the movements of this flexible sheet of cartilage allow the tooth row to conform to irregularities of rock surfaces. In *Microspathodon* the movement of individual teeth is insured by the flexibility of the tooth shaft itself.

All of these forms appear to have separate structures which prevent the individual teeth from rotating sideways during scraping. The tooth joint of *Girella* reduces this possibility. The teeth of *Ophioblennius* have very broad bases and are so intimately attached to one another that little lateral movement is possible. The teeth of *Microspathodon* defeat lateral movement because they are firmly held within the flange system. The common development of the open trough seems to be an effective adaptation to rapid progenic serial replacement. It provides an unobstructed path for the developing tooth eliminating the bone erosion and redeposition evident in fishes possessing tooth replacement from below. The trough structure also provides protection for the tooth primordia.

Rapid serial tooth replacement in grazing fish might well be an adjustment to what would seem to be inevitable and constant losses of whole teeth or dulling of cusps.

The occurrence of progenic serial tooth replacement almost throughout the entire phylogenetic range of teleost fishes is certainly a remarkable case of repeated convergent evolution in this group. The relatively primitive loricariid catfish, *Plecostomus*, possesses structures essentially similar to those found in the highly evolved blennioid,

Ophioblennius, sent for acanthomusillo replacement which arose d

1. T found tooth r of the these b terior along t

2. T are for this tro trough veolar teeth a function

3. E these s developm est tee from 2

4. E species blenni able d and de nigrica well-de within place a and a stantly groups equalit achieve

5. T has be ment c for cer

6. E a blen amine anterior tained largest ject th is sug

Ophioblennius. *Chaenomugil*, *Mugil*, *Xenomugil*, *Girella*, and *Microspathodon* represent forms closer to the parent stock of acanthopterygian fishes. Forms such as *Hermosilla* and *Hypsoblennius* may well possess replacement condition typical of those from which the more specialized grazing dentition arose during the course of evolution.

SUMMARY

1. The percoid fish, *Girella nigricans*, was found to possess an unusual type of serial tooth replacement on the transverse portions of the dentaries and premaxillaries. Each of these bones has a deep trough along its anterior face and a series of vertical flanges along the posterior face of this trough.

2. Tooth primordia, which arise as cusps, are formed just under the anterior margin of this trough within a tissue mass that fills the trough and attaches to the lips and the alveolar margin of the jaw. Larger and larger teeth are found posteriorly with complete functional teeth located between the flanges.

3. Experimental evidence showed that these serial teeth were in constant active development and replacement, with the youngest teeth visible beneath the lips requiring from 22 to 32 days to be replaced and shed.

4. Examination of the jaws of the grazing species, *Microspathodon bairdi* and *Ophioblennius steindachneri*, revealed a remarkable degree of convergence of premaxillary and dentary dentition in both, with *Girella nigricans*. In all three, the anterior trough is well-developed, teeth develop from primordia within the trough and move posteriorly into place along the alveolar margins of the jaws, and are seemingly shed and replaced constantly. The ability of individual teeth or groups of teeth to move closely over inequalities of rock surfaces during grazing is achieved in different ways in each species.

5. The term *progenic serial replacement* has been suggested to describe the replacement condition discovered for these fish, and for certain other species.

6. *Hermosilla azurea*, a kyphosid fish and a blenny, *Hypsoblennius gilberti*, were examined and both found to have a covered anterior trough with serial rows of teeth contained within it. The functional row and the largest replacement teeth were found to project through the bony roof. This condition is suggested as a possible precursor to the

specialized condition found in *Girella*, *Microspathodon*, and *Ophioblennius*.

ACKNOWLEDGEMENTS

We wish to thank Dr. William N. McFarland for his assistance with techniques of anaesthesia. We also wish to express our appreciation to Drs. Carl L. Hubbs, Charles O. Bechtol, and Richard Rosenblatt for assistance with problems of nomenclature.

LITERATURE CITED

- BARNHART, P. S. 1936. Marine fishes of southern California. Univ. California Press. iv + 209 pp.
- EATON, T. H., JR. 1935. The teeth of *Plecostomus*, an armored catfish. *Copeia* 1935(4):161-163.
- . 1951. Comparative anatomy of the vertebrates. Harper and Brothers, New York. viii + 340 pp.
- EBELING, A. W. 1957. The dentition of eastern Pacific mullets, with special reference to adaptation and taxonomy. *Copeia* 1957(3):173-185.
- HUBBS, C. L. 1958. *Dikellorhynchus* and *Kanazawichthys*: Nominal fish genera interpreted as based on juveniles of *Malacanthus* and *Antennarius* respectively. *Copeia* 1958(4):282-285.
- IFFT, J. D., AND D. J. ZINN. 1948. Tooth succession in the smooth dogfish, *Mustelus canis*. *Biol. Bull.* 95(1):100-106.
- JAMES, W. W. 1953. The succession of teeth in elasmobranchs. *Proc. Zool. Soc. London* 123(2):419-474.
- JORDAN, D. S., AND W. F. THOMPSON. 1912. A review of the sparidae and related families of perch-like fishes found in the waters of Japan. *Proc. United States Nat. Mus.* 41(1875):521-601.
- LEVI, G. 1939. Etudes sur le développement des dents chez les téléostéens I. Les dents de substitution chez les genres *Ophidium*, *Trigla*, *Rhombus*, *Belone*. *Arch. D'Anat. Micros.* 35(1):101-146.
- LÜHMANN, M. 1954. Die histogenetischen Grundlagen des periodischen Zahnwechsels der Katfische und Wasserkatzen. (Fam. Anarrhichidae, Teleostei). *Zeit. Zellforschung Mikroskop. Anat.* 40(5):470-509.
- OWEN, R. A. 1840-1845. Odontography, or a treatise on the comparative anatomy of the teeth; their physiological relations, mode of development and microscopic structure in the vertebrate animals. Vol. 1. Hippolyte Bailliere, London. lxxiv + 655 pp.
- . 1866. On the anatomy of vertebrates. Vol. 1. Fishes and reptiles. Longmans, London. xlii + 650 pp.
- TOMES, C. W. 1914. A manual of dental anatomy, human and comparative. H. W. Marett Tims and A. Hopewell-Smith, editors. J. A. Churchill, London. 7th edition. vii + 616 pp.
- MARINELAND OF THE PACIFIC, MARINELAND, CALIFORNIA.

Lestidium johnfitchi, a New Bathypelagic Fish of the Family Paralepididae from off California

ROBERT R. ROFEN

FIVE years ago Mr. John E. Fitch of the California Department of Fish and Game forwarded to me a large adult of a remarkable black paralepidid for identification. It appeared to represent a distinct new species and I have delayed its description in the hope that other specimens would be found. Apparently no others have been caught and the announcement of this new barracudina is best not delayed longer.

Lestidium johnfitchi, *sp. nov.*

Fig. 1.

Holotype.—Stanford University 52109; original number University of California at Los Angeles W53-254; adult 299.0 mm. in standard length collected at East End Anchorage, San Clemente Island, off southern California; obtained by the purse seiner *Tacoma*, in a purse seine with a load of jack mackerel, *Trachurus symmetricus*, in 15 fathoms, on the night of May 24, 1953. The type is in excellent condition.

Description.—The method of description is that used by Harry (1953b), unless otherwise specified.

Body long and slender, strongly compressed, belly slightly rounded in profile; greatest body depth at a point approximately equidistant from pectoral and pelvic fins, 11.5 in standard length. Belly rounded in cross section between head and anal fin; no membranous carina dorsally or ventrally. Caudal peduncle depth 12.6 in standard length, its length from end of anal fin base 4.9 in head length. Anus well behind appressed pelvic fins, under base of anterior dorsal fin rays, situated .24 of eye diameter behind a vertical from dorsal fin origin.

Head long and pointed, barely wider at opercles than body width; its length 4.9 in standard length. Snout long, more than one-half the head length. Nasal apertures situated approximately one-ninth of the upper jaw length before a vertical from posterior tip of maxillary. Eye almost round, its diameter 7.6 into head. Pupil smooth-edged except for a small rounded protuberance at anterior margin. Pupil horizontally oval, somewhat larger than lens. Postorbital length 2.9 in head length. Interorbital flat, its width

8.8 into head, with two compressed, lateral longitudinal ridges on each side; these ridges curve around upper posterior border of eye and terminate before a vertical from posterior edge of eye. Occiput convex, without tubes or flanges on surface. Upper jaw length 1.9 into head, terminating .36 eye diameter before a vertical from orbit.

Premaxillary teeth (see fig. 1b) two (left side) or three (right side) depressible canines followed by 72 (left side) or 69 (right side) closely-spaced, fixed, retrorse teeth. No antrorse canines. Mandible with ten moderately large widely-spaced depressible canines, each accompanied anteriorly by a short fixed tooth. Tongue (see fig. 1e) with two parallel longitudinal rows of teeth posteriorly on glossohyal [This term is used in the same sense as Harry (1953b).]; three teeth in each row. The basyhyal [This term is used in the same sense as Harry (1953b).] has a total of five teeth set irregularly anteriorly in two rows. A very short slit behind last (fourth) gill arch. Gillrakers well developed on first three arches only. On first arch, six rakers (bony plates bearing teeth; those plates without teeth are not counted) on hypobranchial, 17 on ceratobranchial, one multispined raker in angle, and three above angle. Most rakers have 3–5 teeth (see fig. 1d). Upper pharyngobranchial long and slender, with long depressible teeth, approximately two rows in width, more than eight teeth along its length. (The posterior end is situated close to the gill arches and cannot be seen without dissection).

Lateral line with 86 sections on both sides, terminating at a vertical from the twenty-first or twenty-second anal ray. The sections are entirely overlaid with pigment. The ossified center shield is double-concave, indistinct because of heavy pigmentation. Each section has two pores above and below; no median pores. Occasionally there is an inner pair of minute glandular pores medial to the anterior pores (see fig. 1c). The sections remain one to each myotome as far back as a vertical from middle of anal fin; after that they are reduced in size and crowded together.

Dorsal fin origin well behind vertical both from appressed tips of pelvic fins and middle of body length. Dorsal to pelvic distance 2.3

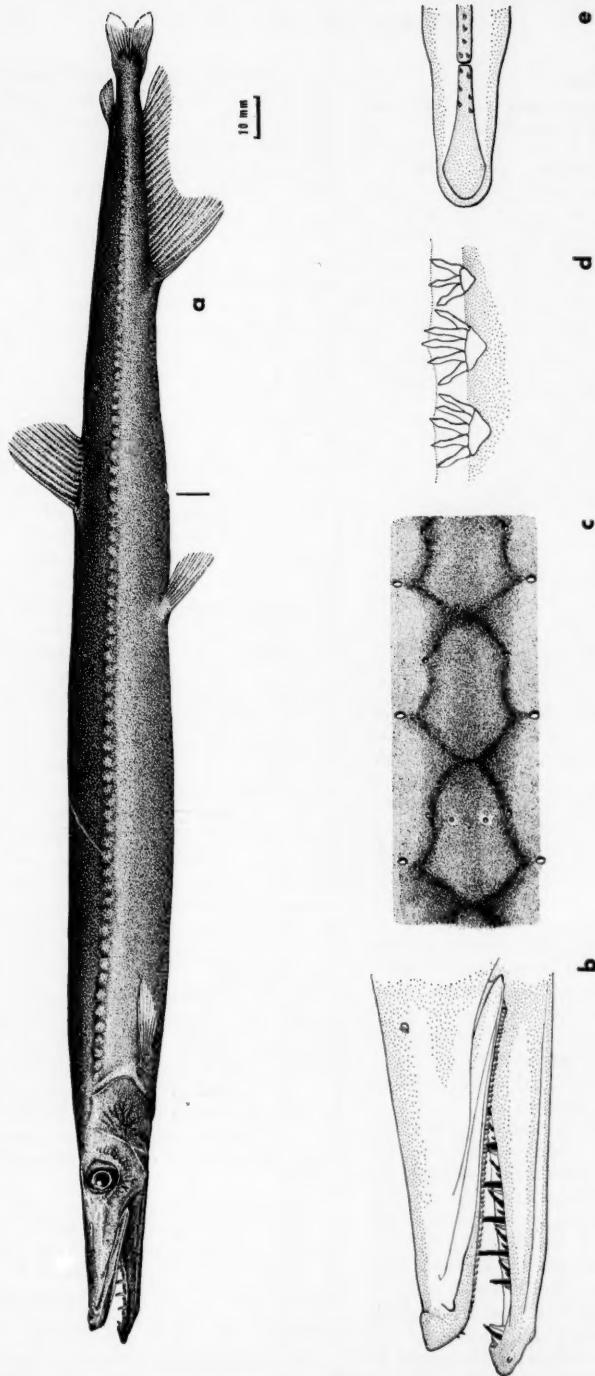


Fig. 1.—Adult of *Lestidium johnficlis* drawn from holotype, Stanford 52109. a. Side view of specimen. b. Anterior part of snout. The mandibular teeth that are solid black are depressible; the remainder of teeth in lower jaw are fixed. c. The anterior lateral-line segments on the left side. While there are normally two pores above and below on each section, occasionally there is a pair of minute glandular pores medial to the anterior pair, as shown on the anteriormost section. d. A section of the ceratobranchial of first arch showing the gillrakers (reduced to rectangular bases) and gill-teeth. e. Dorsal surface of tongue (glossohyal) and anterior portion of basihyal. The small hooked circles indicate the teeth on the tongue.

TABLE 1
COMPARISON OF *LESTIDIUM MIRABILE* (EGE) AND
LESTIDIUM JOHNFITCHI

Character	<i>mirabile</i>	<i>johnfitchi</i>
Pectoral rays	11-13	10
Gillrakers	11-14 + 39-42	3 + 1 + 23
Vertebrae	81-86	98
Lateral-line segments	73-75	86
Position of anus	Behind vertical to dorsal fin base	Under anterior dorsal fin rays
Position of dorsal fin	Over pelvic fin base	Behind appressed pelvic fin rays
Predorsal distance: % S.L.	59.9-61.4 (adults)	65.0
Pectoral fin length: % S.L.	08.3-10.5 (adults)	06.6
Head length: % S.L.	23.7-25.1 (adults)	20.3
Preanal distance: % S.L.	75.9-78.4 (adults)	82.8

in head length. Adipose fin over base of last anal rays, its base constricted. Length of anal fin base 7.3 in standard length. Pectoral fin moderate in size, its length 3.1 in head. Pelvic fins with inner rays distinctly longer than outer.

Coloration.—When first received very dark, blackish. Head, body and fins uniformly dark brown in isopropyl alcohol preservative, darkest anteriorly on snout, entire dorsum, and posterior end of body. Anterior edge of eye with a dark vertical border. No vertical finger-like fleshy protuberance before eye; thus there is no solid black spot such as is often associated with the protuberance in paralepidids of the subgenus *Lestrolepis*.

Relationships.—This new species belongs to the genus *Lestidium* because of the naked body, the single row of teeth on the bony plates on the gill arches, the smooth-edged mandibular teeth, the nostrils situated before a vertical from posterior tip of maxillary, and the number of anal and pectoral fin rays (29 and 10 respectively).

Within the genus *Lestidium*, the new species belongs to the subgenus *Lestidium* because there are no prominent markings before the eye, the anal rays are 29 in number, and the dorsal fin is less than one-half of the head length behind a vertical from the base of the pelvic fins. The new species has a high number of vertebrae (98) similar to the subgenus *Lestrolepis* but lacks the marking before the eye indicative of that group.

The subgenus *Lestidium* is the largest in the genus, containing approximately 16 spe-

cies, as based on an attempted integration of the revisions of Ege (1953) and Harry (1953a, 1953b).¹ Within the subgenus (and genus as well) this new form shares its over-all dark coloration with only one other species, *Lestidium mirabile* (Ege). However, it differs from that species in many ways. The apparent similarity is probably due only to similarity in color and may not be indicative of close relationship.

In general proportions the new species is closest to five described forms: *Lestidium nudum* Gilbert, *L. elongatum* Ege, *L. simile* (Ege), *L. bathyopteryx* (Fowler), and *L. prolixum* Harry. As shown in Table 2, the new species has the anus, dorsal fin, and anal fin situated farther posteriorly than in its close relatives (snout-vent length 55.6-62.1% of standard length versus 66.7 for *johnfitchi*; predorsal distance 59.1-64.8% of S. L. versus 65.0; preanal distance 75.1-80.5% of S. L. versus 82.8). The new species has a greater dorsal-to-pelvic length (8.6% of S. L.) than all its relatives except *L. elongatum* (3.3-6.2 in *L. nudum*, *L. simile*, *L. bathyopteryx* and *L. prolixum*; 10.7 in *L. elongatum*).

The new species appears to be most closely related to *L. simile* and *L. bathyopteryx*. It can be differentiated from the former in snout-vent distance (59.2-60.4% of S. L. in largest specimens versus 66.7 in *johnfitchi*), snout length (7.6-8.1% of S. L. versus 11.0), predorsal distance (58.3-60.4% of S. L. versus 65.0). *L. johnfitchi* can be differentiated from *L. bathyopteryx* in number of gillrakers above angle of first arch (8 in *bathyopteryx* versus 3 in *johnfitchi*), pectoral fin rays (12 versus 10), and position of anus (before a vertical from dorsal fin versus under dorsal fin base).

There is only one form with which it is not possible to compare the new species, *Lestidium gracile* Ege (1953:101) from off New Zealand, which Ege described from postlarvae, the largest specimen 28.3 mm. in S. L. Dr. Ege has been able to give little information to help in comparison of *gracile* with larger and more mature specimens of paralepidids.

This new species is the first in the genus *Lestidium* to be recorded without a well developed ventral carina on the body. However, the presence or absence of a carina is not considered to be of particular importance as a distinguishing character for species of the

¹ Ege's work is based largely upon meristic studies of young fish, while my own (Harry, 1953a, 1953b) deals almost entirely with much larger individuals.

TABLE 2
COMPARISON OF FIVE SPECIES OF THE SUBGENUS *LESTIDIUM* RELATED TO *L. JOHNFITCHI*

Character	I. <i>nudum</i>	II. <i>elongatum</i>	III. <i>simile</i>	IV. <i>bathypetere</i>	V. <i>protium</i>	VI. <i>johnfitchi</i>
1. Pectoral rays	10	11	11-13	12	12	10
2. Anal rays	32-36	28-30	26-33	28	30-31	29
3. Gillrakers	12 + 41	—	—	8 + 28	16 + 30-33	3 + 1 + 23
4. Lateral-line segments	78-82	—	—	70	152-160	86
5. Pores above and below each section	3	—	—	2	4-5	2
6. Position of anus	Before dorsal fin between pelvic fin rays	Before dorsal fin behind appressed pelvic fin rays	Under dorsal fin behind appressed pelvic fin rays	Before dorsal fin, at tips appressed pelvic fin rays	Under 1st or 2nd dorsal fin rays, between tips appressed pelvic fin rays	Under anterior dorsal rays, behind appressed pelvic fin rays
7. Snout-vent distance: % S.L.	58.0	55.6	59.2-60.4	62.1	60.3-61.5	66.7
8. Position of dorsal fin	Behind appressed pelvic fin rays	Behind appressed pelvic fin rays	Behind appressed pelvic fin rays	Over tips of appressed pelvic fin rays	Over tips of appressed pelvic fin rays	Behind appressed pelvic fin rays
9. Dorsal to pelvic length: % S.L.	6.2	10.7 ²	5.9 ³	5.2	3.3-3.7	8.6
10. Predorsal distance: % S.L.	60.3	59.1	58.3-60.4	64.8	59.9-62.7	65.0
11. Head length: % S.L.	21.9	15.7	18.1-19.4	21.7	19.8-21.5	20.3
12. Snout length: % S.L.	11.0	7.4	7.6-8.1	10.9	10.0-10.6	11.0
13. Preanal: % S.L.	76.2	77.3	79.1-79.3	80.5	75.1-77.4	82.8
14. Vertebrae	91	88-91	85-91	—	89	98
15. Prehaemal vertebrae	37	43-45	37-40	—	37	51
16. Prepelvic distance: % S.L.	54.5	48.5	52.1-54.9	59.0	56.2-58.0	57.0
17. General coloration	Lightly pigmented	Lightly pigmented	Lightly pigmented	Lightly pigmented	Lightly pigmented	Solid dark brown or black

I. Based on holotype (see Harry, 1953b, p. 202) and additional material (see Ege, 1953, p. 76).

II. Based on types for counts, holotype for measurements (see Ege 1953, p. 61).

III. Based on type (see Harry, 1953b, p. 201). Holotype 56.5 mm. and paratype 55.2 mm. for measurements (see Ege 1953, p. 88).

IV. Based on type (see Harry, 1953b, p. 201).

V. Based on type (see Harry 1953b, p. 204).

VI. Based on type.

¹ All measurements, except standard length (which is in mm.) are given in percent of standard length.

² Computed from Fig. 10 of type, 58.5 mm. long (Ege 1953, p. 64).

³ Computed from Fig. 18 of type, 56.3 mm. long (Ege 1953, p. 92).

TABLE 3¹
COUNTS AND MEASUREMENTS OF *LESTIDIUM*
JOHNFITCHI

COUNTS	
Dorsal rays	11
Anal rays	29
Pectoral rays	10-10
Pelvic rays	9-9
Gillrakers	3 + 1 + 23 3 + 1 + 23
Lateral-line segments	86-86
MEASUREMENTS	
Standard length	299.0
Body depth	8.7
Caudal peduncle depth	1.6
Caudal peduncle length [Distance between end of dorsal fin base and mid base of caudal fin]	30.4
Snout-vent length	66.7
Head length	20.3
Snout length	11.0
Eye diameter	2.7
Interorbital width	2.3
Upper jaw length	10.4
Predorsal distance	65.0
Dorsal base length	5.2
Dorsal to pelvic distance	8.6
Dorsal to anal distance	18.4
Preal anal distance [Distance between tip of snout and origin of anal fin]	82.8
Anal base length	13.7
Pectoral fin length	6.6
Prepelvic distance	57.0
Adipose to caudal distance	4.1

¹ All measurements, except standard length (which is in millimeters), are given in percent of standard length.

genus *Lestidium*. The lack of carinae in *Lestidium johnfitchi*, its general physiognomy and coloration seems to indicate a greater similarity to *Paralepis* than all other species outside that genus.

Name.—It is a pleasure to name this distinctive barracudina after Mr. John E. Fitch, indefatigable researcher on the California marine fauna, who has helped me greatly in my investigations of inimous fishes.

Luminous organs.—The only known luminous paralepidid fishes are certain species of the genus *Lestidium* which have one or two photogenic ducts situated internally along the ventral region between the isthmus of the gular region of the head and the anus and anal fin. Some species of the subgenus *Lestidium*, including *Lestidium atlanticum*

Borodin and *Lestidium prolixum* Harry, have a single median elongate luminous gland. All known species of the subgenus *Lestrolepis* (*Lestidium intermedium* [Poey], *Lestidium japonicum* Tanaka and *Lestidium pofi* Harry) have a pair of parallel median luminous glands. No species of the subgenus *Lestidiops* have been found to have luminous organs.

The fact that some paralepidids are luminous was made known to me by Dr. Yata Haneda and Dr. Kiyomatsu Matsubara when I was studying fishes in Japan in 1956. They had observed in fresh specimens that the Japanese species of the genus *Lestidium* were internally luminous along the ventral region, glowing with a continuous pale illumination which was self-produced and not caused by luminous bacteria. Dr. Haneda visited our laboratory recently and examined the type of *Lestidium johnfitchi* for the possible presence of luminous organs. No definite photogenic organs as known in the subgenera *Lestidium* and *Lestrolepis* could be discerned and possibly this species is not luminous, although further study should be made when additional material is found.

ACKNOWLEDGMENTS

The George Vanderbilt Foundation at Stanford University has supported this study and provided the funds for illustrations. Mrs. Janet (Roemhild) Canning prepared the side view of the holotype of *Lestidium johnfitchi*. The remaining illustrations are by Mrs. Eva M. Soule, staff illustrator of the George Vanderbilt Foundation. Dr. Boyd W. Walker and the University of California at Los Angeles allowed me to describe this specimen from collections passing through their hands. Dr. G. S. Myers has read the paper and offered suggestions. Dr. Y. Haneda examined the holotype for luminous organs and his results are included.

LITERATURE CITED

- EGE, VILH. 1953. Paralepididae I (*Paralepis* and *Lestidium*) Taxonomy, ontogeny, phylogeny and distribution. *Dana Reports*, No. 40. 184 pp., 33 text figs., 82 tables.
- HARRY, ROBERT REES. (Robert R. Rofen). 1953a. Studies on the bathypelagic fishes of the family Paralepididae. I. Survey of the genera. *Pacific Sci.* 7(2):219-49, 22 text figs.
- . 1953b. Studies on the bathypelagic fishes of the family Paralepididae (Order Iniomii). 2. A revision of the North Pacific species. *Proc. Acad. Nat. Sci. Philadelphia* 105:169-230, 28 text figs., 3 tables.

GEORGE VANDERBILT FOUNDATION AT STANFORD UNIVERSITY, STANFORD, CALIFORNIA.

A New Species of *Labrisomus* from the Caribbean Sea, with Notes on Other Fishes of the Subtribe Labrisomini¹

VICTOR G. SPRINGER

THE purpose of this paper is to bring together information obtained on fishes of the subtribe Labrisomini since my revision of the subtribe (Springer, 1959) went to press. Abbreviations and methods of counting and measuring are the same as described in that paper. All measurements are in millimeters.

Labrisomus (*Gobioclinus*) *filamentosus*,
sp. nov.

(Fig. 1)

The holotype, USNM 185618, and only known specimen, is an adult male collected by the U. S. Fish and Wildlife Service vessel *M. V. Oregon* at station 1874: 16° 43' N. latitude, 81° 57' W. longitude at a depth of fifty fathoms on August 22, 1957.

Description.—Dorsal XXI, 12; anal II, 19 (injured, the actual count was probably II, 21); pectorals 13; pelvics I, 3; caudal 13; lateral-line scales, left 65, right 66, gill rakers on first gill arch 11 including nubs; branchiostegal rays 6; symphysial pores 2.

Standard length 76.0 (it is estimated that an error of 1 or 2 mm. may be involved due to the impossibility of rendering the specimen normal). Head length 23.0. Bony orbital diameter 7.0. Snout length 7.0. Maxillary length 10.6. Caudal peduncle 6.2. First dorsal spine (d.s.) 31.5; second d.s. 28.8; third d.s. 25.0; fourth d.s. 11.8; fifth d.s. 9.8; tenth d.s. 11.5; twentieth d.s. 10.0; twenty-first d.s. 9.5. Longest dorsal ray 16.2. First anal spine 4.0; second anal spine 5.4. Longest caudal ray 19.0. Longest pectoral ray 23.6. Longest pelvic ray 25.3; shortest pelvic ray 7.5. Nuchal cirri base 0.7; interspace 3.0.

The first three dorsal spines are long and flexible, and bear fleshy flags; the membrane between the first and second and the second and third spines is incised to half the distance from the base of the fin. The membrane is only slightly incised between the remaining spines. The last ray is bound to the caudal base.

The membranes between the anal rays are incised from one-quarter to two-fifths the distance from the base of the fin. The anal is free from the caudal.

The membranes between the pectoral rays and the pelvic rays are incised as much as three-fifths the lengths of the rays.

There is a single well-developed outer row of teeth in each jaw followed by a patch of much smaller teeth. The palatine teeth are of about the same size as the outer row in the jaws and are larger than those on the vomer. There are no enlarged teeth medially behind the outer row in either jaw.

The preopercular lateral-line canal scarcely encroaches on the opercle. There are no scales on the opercle.

The nasal cirri are simple; each supraorbital cirrus is in the form of a fleshy tab with a shredded margin; the nuchal cirri are three-parted.

The pattern is best discerned from the plate. A color slide of the holotype taken by Mr. H. R. Bullis when the specimen was fresh indicates that the lighter and darker bands on the body were shades of brown. The head and venter were also brown. There was a faint yellow band passing posteroventrally from the eye across the opercle. The ocellus was black. On the cheeks and branchiostegal membranes were some light orange spots. The distal margin of the dorsal fin was strikingly marked with bright orange-yellow splotches. The remainder of this fin and all of the other fins except the caudal were deep dusky brown. The caudal is not visible on the slide.

Discussion.—This species is most closely related to *Labrisomus* (*Gobioclinus*) *dendriticus* (it will key to that species in my 1959 key), which is known only from the Galapagos Islands of the eastern Pacific. The relationship of these two species points out additional evidence of the close faunal affinities of the Galapagos with the tropical western Atlantic.

Hubbs (1953) segregated *L. dendriticus* into the subgenus *Odontoclinus* which I (Springer, *op. cit.*) synonymized with the subgenus *Gobioclinus*. The high scale count and the long first three dorsal spines of *L. dendriticus* and *L. filamentosus* could serve to segregate these two species into a separate subgenus (*Odontoclinus*) from the remaining *Gobioclinus*, but I do not feel that the differences are as significant as those separating the three subgenera that I recognized.

¹ Contribution Number 30.

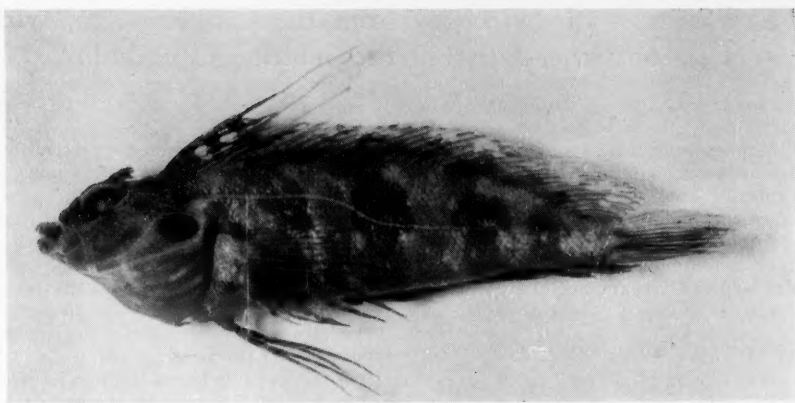


Fig. 1.—Holotype of *Labrisomus (Gobioclinus) filamentosus*, USNM 185618.

Labrisomus filamentosus differs from *L. dendriticus* in having the first three dorsal spines much longer (first dorsal spine about twice the longest dorsal ray length in *L. filamentosus*; about equal in *L. dendriticus*); in having longer pelvics and pectorals with their rays deeply incised; in not having enlarged retrorse canines medially in each jaw; and in having a barred color pattern, in contrast to the uniform color pattern described for *L. dendriticus*. The 21 spines of the dorsal are one more than has been recorded for *L. dendriticus*.

This species is named *filamentosus* in reference to the long, filamentous first three dorsal spines.

I wish to thank Harvey R. Bullis and Loren P. Woods for calling this specimen to my attention and allowing me to describe it. The photograph was taken by Mr. John W. Terge- sen.

Labrisomus philippii Steindachner

On my (Springer, *op. cit.*) map depicting the distribution of this species I inadvertently omitted Delfin's (1901) record from the Chilean coast just above 30° south latitude.

Morrow (1957) reported this species from several Peruvian localities. In the same paper he also reported *Malacoctenus afueræ* from Sequion Bay, Bahía Paracas, Peru. Through his permission I have examined his specimens of *M. afueræ* and find them to be juvenile specimens of *L. philippii*.

Complete dentition does not develop in the subgenus *Labrisomus* until adulthood. Also color pattern frequently fails to appear

until individuals attain a size of about 20–30 mm. In *Malacoctenus* the smallest specimens (about 10 mm.) I have seen show color pattern approximating that of the adult. Morrow's specimens had juvenile dentition which could be either *Labrisomus* or *Malacoctenus*, but his specimens (17.6–18.2 mm.) only showed slight chromatophore development. Pectoral counts on Morrow's specimens were L. 15, R. 15 in all but one specimen, which was L. 14, R. 15. These figures are characteristic of *L. philippii*, but not *M. afueræ*, which has an almost constant count of L. 14, R. 14.

Labrisomus trinidadensis Pinto

Pinto (1957) described this species from Trindade (not Trinidad) Island off the eastern coast of Brazil. He separated this species from *Labrisomus nuchipinnis* by the nature of its dentition and the structure of its jaws. He did not state what the differences were, but merely remarked that they can be noted when series of each species (using *L. nuchipinnis* from Brazil) are compared. In his introductory paragraph he stated that his species might not be new, but that at least he would have given a complete description of the form.

My (Springer, *op. cit.*) own examinations of *Labrisomus nuchipinnis* dentition showed a considerable amount of variation and I was never able to demonstrate any consistent population differences in this character. (I was, however, able to demonstrate meristic differences of infrasubspecific order.) Pinto's figures do not indicate any particular differ-

ences
species
zilian

Hul
which
pinnis
nuchi
mens
(Can
of the
mens,
At th
trinda
nuchi
Brazil
conne
wester
pinnis

So

Bee
genus
a sing
though
course
was so
tain a
ognize
of the
ever,
specim
ture o
genera
of sca
mm.;
crepan
have
state o
condit
thus b

Thi
Fowle
pictur
(Sprin
type,
small
*Malac
cocten
ray c
counts
(dama
Fowle
above
macro
tenus,
homor*

ences from *L. nuchipinnis* as I know that species, but I do not have his series of Brazilian and Trindadean specimens before me.

Hubbs (*op. cit.*) stated that *L. canariensis*, which I considered a synonym of *L. nuchipinnis*, had a dentition different from *L. nuchipinnis*, but he examined only two specimens (*personal communication*) of the former (Canary Islands) and a small series (Panama) of the latter. I examined all Hubbs' specimens, but could not reaffirm his observations. At the present it is my opinion that *L. trindadensis* should be synonymized with *L. nuchipinnis*. Trindade is well off the coast of Brazil and it is possible that it serves as a connecting link between the eastern and western Atlantic populations of *L. nuchipinnis*, which species has a planktonic larva.

Somersia furcata Beebe and Tee Van

Beebe and Tee Van (1934) described this genus and species as a "scaleless blenny" from a single small specimen from Bermuda. Although I examined the holotype during the course of my labrisomine work, its condition was so degenerated that I was unable to obtain any information from it, or even to recognize its general affinities. Re-examination of the original description and figure, however, readily indicates that this is a young specimen of *Labrisomus nuchipinnis*. The nature of the maxillary, fin ray counts, and general appearance place it here. The lack of scales is explained by its small size: 20.3 mm.; they have not yet formed. The only discrepancy is the forked caudal which could have been due to damage, if the present state of the specimen is any indication of its condition at the time of description. *Somersia* thus becomes a synonym of *Labrisomus*.

Entomacrodops macropus Fowler

This genus and species was described by Fowler (1944) but because of a misleading picture and description it was overlooked (Springer, *op. cit.*). Examination of the holotype, and only specimen, shows it to be a small specimen in poor condition of either *Malacotenus margaritae mexicanus* or *Malacotenus hubbsi polyporus*, based on fin-ray counts and general morphology. My counts for the specimen: D. XX, 11 or 12 (damaged); A. II, 21; Pec. R. 14, L. 14. Fowler's name holds priority over both of the above subspecies, but inasmuch as *Entomacrodops* becomes a synonym of *Malacotenus*, the name *macropus* becomes a junior homonym of *M. macropus* (Poey) and must

be suppressed. Fowler's specimen was made available to me by J. Böhlke who also discussed the above action with me.

Appreciation is due D. K. Caldwell, L. P. Woods, J. Randall, and C. R. Robins for permission to record the range extensions below. None of these extend into any of those areas delineated by me (Springer, *op. cit.*) as being devoid of labrisomine fauna.

UF refers to collections made by D. K. Caldwell to be deposited in the collections at the University of Florida.

Labrisomus nuchipinnis. Serrana Bank, Caribbean Sea, CNHM 64373.

Labrisomus haitiensis. St. John, Virgin Islands, UMML (no number).

Labrisomus bucciferus. Jamaica, UF (several lots), CNHM 62201, 62209, 62217, 62220; Haiti, CNHM 62228, 62234, 62238; Serrana Bank, CNHM 64370; Panama, CNHM 62197; Florida, Ajax Reef, UMML 5259.

Labrisomus guppyi Jamaica, UF (several lots), CNHM 62207, 62210, 62212, 62213, 62214, 62215, 62216, 62217, 62218, 62219, 62220, 62221, 62222, 62223, 62224, 62225, 62226, 62227; Serrana Bank, CNHM 64372; Panama, CNHM 62198; Florida, Monroe Co., Alligator Reef, UMML 2558.

Labrisomus gobio. St. John, Virgin Islands, UMML (no number); Serrana Bank, CNHM 64371.

Labrisomus nigricinctus. Jamaica, CNHM 62202, UF (several lots); Haiti, CNHM 62229; Puerto Rico, CNHM 62252.

Malacotenus boehlkei. St. John, Virgin Islands, UMML 4918.

Malacotenus erdmanni. Jamaica, UF; Haiti, CNHM 62236, 62240.

Malacotenus gilli. Jamaica, UF (several lots), CNHM 62204, 62211, 62213, 62215, 62218; Serrana Bank, CNHM 64375.

Malacotenus aurolineatus. Jamaica, UF (several lots); Haiti, CNHM 62239; Serrana Bank, CNHM 64374.

Malacotenus versicolor. Jamaica, UF.

Malacotenus delalandei. Haiti, CNHM 62225.

Malacotenus triangulatus. Jamaica, UF (several lots); Haiti, CNHM 62230; St. John, Virgin Islands, UMML (no number).

Malacotenus ebisui. Acapulco, Mexico, CNHM 62266, 62275.

ERRATA FOR "SYSTEMATICS AND ZOOGEOGRAPHY OF THE FISHES OF THE SUBTRIBE LABRISOMINI HUBBS"

Inasmuch as this paper is meant to bring together all information obtained on fishes of the Labrisomini since my revision. I take

this opportunity to correct several errors and oversights that appeared in the revisionary study (Springer, V. G. 1959. Systematics and Zoogeography of the fishes of the subtribe Labrisomini Hubbs. *Publ. Inst. Marine Sci.* 5:417-492). The publication is dated December, 1958; but the first large mailing of the journal containing my article was made on or about June 25, 1959.

- P. 429. Under *Material* read "27 from Texas" instead of 23.
- P. 425. Under footnote 4 will be found the portion of the couplet 00 missing from the key on the same page.
- P. 434. Under *Material* add after Bahamas: ANSP 74713, 74724.
- P. 436. Under *Material* add after Tortugas: USNM 114713.
- P. 437. Under *Material* add after Bahamas: ANSP 74715-16 and 74675.
- P. 439. Under *Material* add after Bahamas: UM 845, 888.
- P. 440. In key couplet AA "center" should read "venter." In (AA) "contous" should read "contour."
- P. 441. In key couplet D "impedded" should read "imbedded."
- P. 446. After *Material* read: "Six-hundred seven specimens" instead of 614, 19 from Miami instead of 10.
- P. 447. (con't from p. 446) 152 from Tortugas instead of 162. USNM 92579 should read USNM 92597; BMNH 1920.12.174-83 should read BMNH 1920.12.22.174-183; BMNH 1923.7.30.3.3-4 should read BMNH 1923.7.30.313-4; Add to material BMNH 72.8.28.54-55 and ANSP 74503.
- P. 448. Under *Material* and after Bahamas omit USNM 114707, but not after Cuba.
- P. 453. After *Material* read "Two-hundred eighty-four" instead of 281, and 90 from Puerto Rico instead of 86. In Table 3 "Dorsal" and "Anal" should be switched and anal elements for Bahamas should read 36 36 3 instead of 34 33 3.
- P. 455. After *Material* read "One-hundred seventy-three" instead of 175. UZMK P76991 should read UZMK P7699; after Bahamas add UM 851, 890, 892.
- P. 456. Seventh line from bottom "*L. nuchipinnis*" should contain one "p."
- P. 460. After *Paratypes* read "Eight-hundred forty" for 846; read "Five-hundred seventeen from... Punta Peñasco" instead of 513...; UCLA W54-20 should read UCLA W56-20. Add the

following (information on these lots is included in the species description): UCLA W54-262, SU 49632, 49633.

- P. 466. After *Paratypes* read "Two-thousand six-hundred three" instead of 2593. After Moreno Rocks 49664 should read SU 49664.
- P. 468. (continuation from p. 466) CNHM 42685 should read CNHM 42658. Add as paratypes SU 16608 (information on these is included in the description).
- P. 474. After *Material* SU 2981 should read SU 2891.
- P. 476. After *Paratypes* read "Three-hundred forty-three" instead of 344. CNHM 61898 should read CNHM 61904. Add SU 49694 after Pacheca, Perlas Islands. Add at end of list: 5 from Cape San Francisco, Ecuador: SU 37586. Information on these last two lots is included in the description.
- P. 478. After *Paratypes* read "Two-hundred fifty-seven" instead of 253; "Twenty-two from Tortugas" instead of 23; add for Tortugas USNM 114760 "188 from the Bahamas" instead of 177 (ae's were meant to be hyphens). ANSP 74479-93 should read ANSP 74479-83; BMNH 1939.5.12.179-190 should read BMNH 1939.5.12.179.

LITERATURE CITED

- BEEBE, WILLIAM, AND JOHN TEE VAN. 1934. A new genus and species of scaleless blenny, *Somersia furcata*, from Bermuda. *Amer. Mus. Novit.* No. 730. 3 pp.
- DELFIN, FÉDERICO T. 1901. Catálogo de los peces de Chile. *Rev. Chilena Hist. Nat., Valparaíso*, vols. 2-4 (1898-1900). Reprinted with new pagination. *Valparaíso*, 1901. 133 pp.
- FOWLER, HENRY W. 1944. Results of the Fifth George Vanderbilt Expedition (1941).... The fishes. *Acad. Nat. Sci. Philadelphia Monograph* 6:57-529.
- HUBBS, CLARK. 1953. Revision of the eastern Pacific fishes of the clinid genus *Labrisomus*. *Zoologica* 38(3):113-136.
- MORROW, JAMES E. 1957. Shore and pelagic fishes from Peru, with new records and the description of a new species of *Sphoeroides*. *Bull. Bingham Oceanog. Coll.* 16(2):5-55.
- PINTO, SÉRGIO. 1957. Um novo Clinidae da Ilha da Trindade, Brasil. *Bol. Mus. Nac., Rio de Janeiro* 163:1-15.
- SPRINGER, VICTOR G. 1959. Systematics and zoogeography of the clinid fishes of the subtribe Labrisomini Hubbs. *Publ. Inst. Marine Sci.* 5:417-492.

FLORIDA STATE BOARD OF CONSERVATION MARINE LABORATORY, ST. PETERSBURG, FLORIDA.

A New Eel of the Genus *Kaupichthys*¹

KIYOMATSU MATSUBARA AND HIROTOSHI ASANO

AMONG many species of apodal fishes obtained in our recent expedition to the Amami Islands, southern Japan, are two species referable to *Kaupichthys* Schultz, a genus not previously recorded from Japan. A new eel is described herein under the name, *Kaupichthys diodontus japonicus*, which in many important features closely resembles both *K. diodontus* Schultz (1943:50) and *K. atlanticus* Böhlke (1956:66). The other species seems identical with *K. atronassus* Schultz (1953:65) known from the Marshall Islands, though it differs somewhat from the latter in several proportional characters, discussed below. In order to delimit properly the new form, we have included a redescription of *K. atronassus* and compared the two forms in detail.

When Schultz (1943:50) erected the genus *Kaupichthys* based on *K. diodontus* as type species, he included it in the family Echelidae. Gosline (1950, 1951, 1952), working with the osteology of *Chilorhinus*, *Kaupichthys*, and *Garmanichthys*, proposed the name Chilorhinidae for the three genera. Recently, however, Böhlke (1956:64) included *Kaupichthys* in the Xencongridae, making reference to many investigators' papers and specimens concerned with the above-mentioned genera and other related ones. It is an interesting problem whether *Kaupichthys* belongs to the Echelidae, to the Xencongridae or to some other family. Inasmuch as the matter is not the aim of this paper, we have not pursued the problem. To find out the important characteristics by which the relationship or phylogenetic pedigree in the evolution of eels may be surmised, it would be necessary to examine most related eels, a study we are not prepared to undertake at present.

Counts and measurements of the bodily parts were made according to the standard practice as outlined by Matsubara (1955:60-69).

Kaupichthys diodontus japonicus, subsp. nov.

(Figs. 1 and 2 A, B)

Holotype.—MIKU (Marine Biological Institute of Kyoto University) 1748, a ripe fe-

male with full-grown ova, 238.0 mm. in total length, collected from a coral head near Kametsu, Tokunoshima, the Amami Islands, on July 15, 1958.

Paratype.—1 specimen. MIKU 1749, a ripe female with full-grown ova, 237.0 mm. in total length, collected together with the holotype.

Description.—Pectoral rays 14 (14 in paratype). Vertebrae 109 (109). Head 7.2 (7.2) in total length; greatest depth of head 15.8 (15.9); greatest width of head 22.0 (26.3); distance from tip of snout to vent 3.4 (3.3); depth of body immediately before vent 16.1 (16.9); width of body in the same portion 18.3 (23.7); distance from vent to tip of tail 1.4 (1.4). Greatest depth of head 2.2 (2.2) in head length; depth of body immediately before vent 2.2 (2.4); snout 4.4 (4.3); eye 9.4 (9.2); interorbital width 4.7 (4.9); distance from snout tip to rictus 2.4 (2.5); distance between anterior nostrils 10.3 (11.0); distance between posterior nostrils 5.1 (5.4); distance from tip of snout to origin of dorsal fin 0.9 (0.9); length of pectoral fin 6.6 (5.4); distance between gill openings measured on ventral side 3.2 (4.1). Head 1.2 (1.2) in length of trunk. Length of head and trunk 2.4 (2.3) in tail length. Eye 2.1 (2.1) in snout.

Body roundish in cross section anteriorly, becoming progressively narrower toward end of tail. Head a little shorter than trunk. Snout moderately long, depressed, rounded dorsally, the tip blunt and slightly projecting beyond lower jaw when mouth is closed. Lips without free flange. Eye moderately large, the diameter about 2.1 times in length of snout. Interorbital space broad, slightly arched, the narrowest fleshy part 4.7-4.9 times in head length, and about twice as wide as eye diameter.

Anterior nostril tubular, on sides near snout tip, directing antero-ventrally. Posterior nostril with a valvular flap, opening on upper lip immediately before and below anterior margin of eye, and directed backwards and downwards.

Mouth large, horizontal, the gape extends far beyond posterior margin of eye. Teeth conical in shape, but rather blunt (Fig. 2 A, B). Maxillary teeth in three or four irregular rows anteriorly, becoming two or three rows posteriorly; the teeth progressively higher from the outer series inwards. Premaxillary

¹ Contributions from the Marine Biological Institute of Kyoto University, No. 3. The Institute is located at Tannawa, Sennan-gun, Osaka Prefecture. It was established for our Department by Nankai Electric Railway Co., Ltd. on March 20, 1958. We wish to express our sincere acknowledgements to the Company for their generous financial assistance.

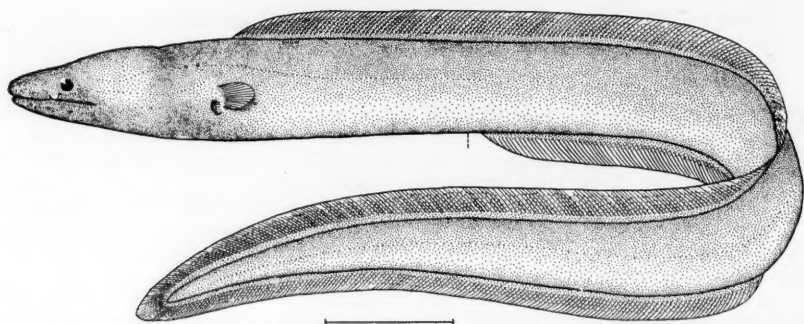


Fig. 1.—Lateral aspect of holotype of *Kaupichthys diodontus japonicus*. Scale bar indicates 20 mm.

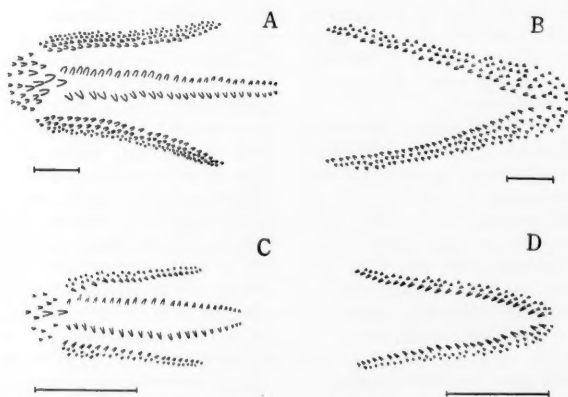


Fig. 2.—Dentition in two forms of *Kaupichthys*. A and B, from female paratype of *K. diodontus japonicus*. C and D, from *K. atronatus* Schultz. Scale bars indicate 2 mm.

teeth set in a rather large patch, the posterior and inner five to six ones somewhat enlarged. Vomerine teeth in two widely separated uniserial rows that are closest together posteriorly, and extend backwards far beyond the posterior ends of maxillary band of teeth. Mandibular teeth in a broad band with about four or five rows anteriorly and two or three posteriorly, the inner teeth larger than the outer ones. Tongue adnate to floor of mouth.

Sensory pores on head fewer than in congrid eels, the numerous pit organs widely scattered on head. Supraorbital canal with three pores near tip of snout, the anteriormost pore small, opening immediately before the anterior nostril, the others situated respectively before and behind the upper part of the anterior nostril. Infraorbital canal with four pores running near lower edge of upper

lip; the anteriormost two set between anterior and posterior nostrils, and the others behind posterior nostril just below eye. Mandibular canal furnished with six pores set in a series between tip of lower jaw and below rictus, the anteriormost one small. The anteriormost two pores of lateral line on branchial region very large, but the others very small, numerous, on low papillae like those of pit organs, continuing from branchial region to end of caudal fin.

Dorsal fin rather high, begins at a vertical above middle of pectoral. Anal fin also high, begins shortly behind vent. Caudal fin moderately large, nearly as long as pectoral fin, and confluent with both dorsal and anal fins. Pectoral fin moderately large, but much shorter than snout. Gill openings well-separated, roundish, placed in front of lower half of base of pectoral fin.

Color
through
little da
fins and

Habi

were co
mention
meters
angry v
pool w
surround
posite
fine sa
meters
specimen
spawn

Disc

lated t
Marsha
Islands
the Ba
only c
forms
mens
97 to
lantic

Acco
verteb
10 in
Ochia
confid
count
from
been
seque
the v
of Ka
may l
either
diffic
of va
speci
ing u
pled
ent
speci
bral
conc
ogni
form
tribu
On
doub
are
no a
yet;
fers
lowi

Color in formalin.—Body brownish throughout, tips of snout and lower jaw a little darker. The distal margins of median fins and pectoral fin whitish.

Habits and habitat.—Only two specimens were collected from a coral head of the aforementioned locality. The place is about 200 meters away from the shore, and faces to the angry waves of the Kuroshio Current. The pool where the specimens were collected is surrounded on three sides by a large composite of coral heads and is bottomed with fine sand, its deepest portion being about 3 meters deep at the ebb tide. If judged by specimens which contain ova, this form may spawn in summer.

Discussion.—This subspecies is closely related to *K. diodontus*, which occurs in the Marshall, Samoan, Hawaiian, and Philippine Islands, and is related to *K. atlanticus* from the Bahamas. The number of vertebrae is the only character that distinguishes these three forms from one another. In both of our specimens the vertebral counts are 109 as against 97 to 98 in *K. diodontus* and 119 in *K. atlanticus*.

According to Jespersen's data (1942) the vertebral counts in anguillid eels vary about 10 in the 16 species examined. Matsubara and Ochiai (1951:255) statistically estimated the confident limits of variation of vertebral counts in *Synaphobranchus kaupii* to range from 138 to 154. Similar evidence has also been observed in Japanese congrid eels. Consequently, there is a general tendency that the vertebral counts of this group inclusive of *Kaupichthys* are extremely variable, which may lead one to identify our specimens with either *K. diodontus* or *K. atlanticus*. But it is difficult to do so, because the probable range of variation of the vertebral counts in these species cannot be presumed for the time being until some future investigator has grappled with this problem. At any rate the present form is intermediate between the two species mentioned above, so far as this vertebral character is concerned. We, therefore, conclude that our *Kaupichthys* should be recognized at least as a subspecifically distinct form of *K. diodontus*, in view of the distributional pattern.

On the other hand, one may entertain a doubt as to whether or not our specimens are merely adults of *K. atronassus* Schultz, as no adult specimens of the species are known yet; but the present form undoubtedly differs from that form at least in having the following important characters: (1) pectoral rays

14 (11 in the latter); (2) head deeper, the deepest part 15.8 to 15.9 in total length (20.9 etc.); (3) body also deeper, the deepest part at vent 16.1 to 16.9 in total length (21.3); (4) body wider, the width at vent 18.3 to 23.7 in total length (37.7); (5) eye larger, the diameter 9.2 to 9.4 in head length (12.5); (6) interorbital space wider, 4.7 to 4.9 in head length (7.9); (7) distance between gill openings measured on the ventral side wider, 3.2 to 4.1 in head length (5.8).

Kaupichthys atronassus Schultz

(Figs. 2 C, D and 3)

Kaupichthys atronassus Schultz, 1953, U. S. Nat. Mus. Bull. (202), 1:65, fig. 14 (type locality: lagoon coral head at north end of Rongelap Island, Rongelap Atoll, Marshall group; lagoon reef of Namu Island, Bikini Atoll of the same group).—Böhlke 1956, Proc. Acad. Nat. Sci. Philadelphia 153:65 (key, notes, and distribution).

Material examined.—1 specimen, MIKU 1750, 110.8 mm. in total length, coral head near Sômachî, Kikai Island, the Amami Islands, on July 7, 1958.

Description.—Pectoral rays 11. Vertebrae 110. Head 7.4 in total length; greatest depth of head 20.9; greatest width of head 26.4; distance from snout tip to vent 3.8; depth of body immediately before vent 21.3; width of body at the same portion 37.0; distance from vent to tail end 1.4; same from snout tip to origin of dorsal fin 6.5. Greatest depth of head 2.8 in head length; greatest depth of body 2.8; depth of body immediately before vent 2.9; snout 5.0; eye 12.5; interorbital width 7.9; distance from snout tip to rictus 3.0; distance between anterior nostrils 10.0, between posterior nostrils 5.6; distance from snout tip to origin of dorsal fin 0.9; length of pectoral fin 5.6; distance between gill openings measured on the ventral side 5.8. Head 1.2 in length of trunk. Length of head and trunk 2.3 in tail length. Eye 2.5 in snout.

Body slender and moderately elongate, the head region nearly roundish in cross section, becoming narrower towards tip of tail. Head a little shorter than trunk. Snout moderately long, somewhat depressed, broadly rounded dorsally, the tip bluntly pointed and slightly projecting beyond lower jaw when mouth is closed. Lips without free flange. Eye small, without conspicuous free margin, the diameter about 2.5 times in length of snout. In-

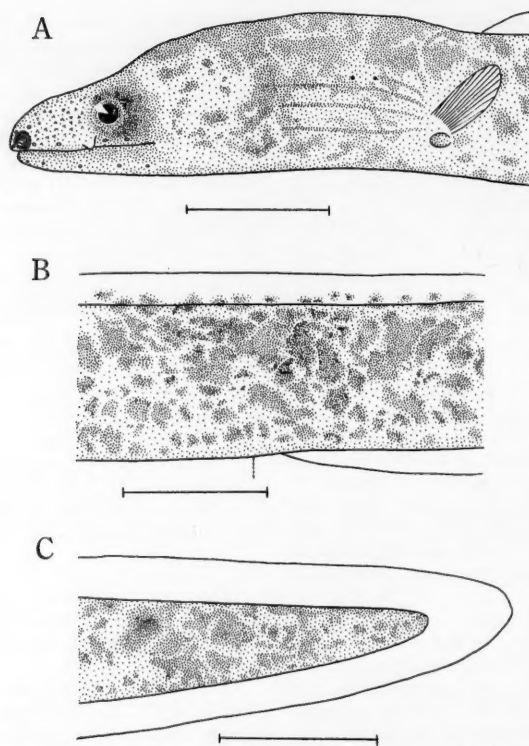


Fig. 3.—Head (A), trunk (B) and tail (C) of *Kaupichthys atronatus* Schultz, showing the color patterns. Scale bars indicate 5 mm.

terorbital space broad and rather flattish, a little wider than diameter of eye.

Anterior nostril tubular on lateral side near tip of snout, directed antero-laterally. Posterior nostril with a valvular flap, opening on upper lip just before and below anterior margin of eye, and directed backwards and downwards.

Mouth rather large, horizontal in direction, the gape extending far beyond posterior margin of eye. Teeth rather sharp and conical in shape (Fig. 2 C, D); those on maxillary about three rows anteriorly and two rows posteriorly, the outer ones much smaller than the inner ones; teeth on dentary in a band, about three rows anteriorly and two rows posteriorly, the inner ones larger than the outer ones; premaxillary teeth in a patch, the two central ones enlarged; vomerine teeth in two widely separated uniserial rows, farthest apart near their middle length, and the posterior end of these rows closest together far behind the level of posterior extremities of max-

illary bands of teeth. Tongue adnate to floor of mouth.

Sensory pores on head few in number, but numerous pit organs widely scattered on surface of head. Supraorbital canal provided with only three pores near tip of snout; the anteriormost one opening on antero-ventral part of anterior nostril, and the other two lying on dorsal side of it. Infraorbital canal furnished with four pores, closely set on ventral margin of upper lip; the anteriormost two lying between nostrils and the others behind posterior nostril just below eye. Mandibular canal with six pores; the anteriormost small one opening at the tip of lower jaw, the remaining ones spacing progressively farther and the posteriormost one located vertically below rictus. Lateral line inconspicuous and the pores scarcely discernible except for the anteriormost two on branchial region.

Dorsal fin high, the origin above a vertical through middle of length of pectorals. Anal

also h
Cauda
as snout
anal
little
ish an
tral h
rated
side.

Col
larly
the co
dorsal
side.
part o
part
around

Ha
previo
(Schu
the tw
head
Thro
Island
specie
obtain
Kikai
of the
dence
in a m
teristi
lands
often
and s
cies a
lands
Pacifi

Dis
the te
in the
indivi
of the
atlan
specie
basis
also c
donta
imma

also high, its origin immediately behind vent. Caudal fin moderately large, nearly as long as snout, and confluent with both dorsal and anal fins. Pectoral fin well-developed, but a little shorter than snout. Gill opening roundish and pore-like in shape, placed below ventral half of pectoral fin base, and widely separated from the counterpart of the opposite side.

Color in formalin.—Body whitish, irregularly speckled or mottled with light brown, the colored areas larger and more compact dorsally as compared with those of ventral side. The colored areas extending along basal part of dorsal fin; all other fins whitish. Basal part of anterior tubular nostrils and area around their base blackish (Fig. 3).

Habits and habitat.—This small eel has previously been known by authentic records (Schultz, 1953:65; Böhlke, 1956:65) only from the two specimens caught in a lagoon coral head or lagoon reef of the Marshall Islands. Throughout our expedition to the Amami Islands extending over a month only a single specimen of this particular species has been obtained from a coral head near Sômachî, Kikai Island. Rarity seems to be characteristic of the members of *Kaupichthys*. Similar evidence has been observed by Böhlke (1956:70) in a related form of this genus. This characteristic contrasts at least in the Amami Islands with that of muraenid eels, which were often found in great numbers in the same, and similar, rocky areas searched. This species appears to be indigenous to oceanic islands of the tropical and subtropical western Pacific.

Discussion.—According to Böhlke (1956:67), the teeth of *K. atlanticus* differ with the sexes in the number of rows and the nature of the individual teeth. His description and figures of the dentition of a female paratype of *K. atlanticus* hold good with our mature female specimens of *K. diodontus japonicus*. On the basis of the mandibular dentition, Böhlke also considered that the holotype of *K. diodontus* Schultz is apparently a female. Our immature specimen of *K. atronatus* may be a

male, because the mandibular teeth agree well with those of a male paratype of *K. atlanticus*, as illustrated and described by Böhlke.

Although the specimen treated here is slightly larger than those described by Schultz (1953:65), the former differs from the latter in having higher body, shorter snout, larger eye, and longer pectoral than the latter (depth at the deepest part 27 to 31 in total length and 3.5 to 4.1 in head length; snout 4.4 to 4.5 in head length; diameter of eye 14.0 to 15.0; pectoral 6.1 to 7.8 in the latter), but it is impossible to determine whether these differences between the two are anything more than individual variation until we have available material enough to make a more thorough comparison of the species.

LITERATURE CITED

- BÖHLKE, JAMES E. 1956. A synopsis of the eels of the family Xenocongridae (including the Chlopsidae and Chilorhinidae). *Proc. Acad. Nat. Sci. Philadelphia* 153:61-95, 8 figs., 1 pl.
- GOSLINE, WILLIAM A. 1950. The osteology and relationships of echelid eel, *Kaupichthys diodontus*. *Pacific Sci.* 4(4):309-314, 7 figs.
- . 1951. *Chilorhinus brocki*, a new echelid eel from Hawaii, with notes on the classification of the order Anguillida. *Copeia* 1951(3): 195-202, 1 fig.
- . 1952. Notes on the systematic status of four eel families. *Jour. Washington Acad. Sci.* 42(4):130-135, 2 figs.
- JESPERSEN, POUL. 1942. Indo-Pacific leptocephalids of the genus *Anguilla*. Systematic and biological studies. *Dana-report* 4(22):1-128, 83 figs., 4 pls.
- MATSUBARA, KIYOMATSU. 1955. Fish morphology and hierarchy. Pt. I. xi + 789 pp. Tokyo.
- , AND AKIRA OCHIAI. 1951. Notes on the eels of the genus *Synaphobranchus* found in Japanese waters. *Jap. Jour. Ichth.* 1(3):251-259, 4 figs.
- SCHULTZ, LEONARD P. 1943. Fishes of the Phoenix and Samoan Islands collected in 1939 during the expedition of the U. S. S. *Bushnell*. *U. S. Nat. Mus. Bull.* 180. x + 316 pp., 27 figs.
- . 1953. Order Anguillida: Eels. In *Fishes of the Marshall and Marianas Islands*. 1. (L. P. Schultz, ed.) *U. S. Nat. Mus. Bull.* 202:43-159, 29 figs.

KYOTO UNIVERSITY, MAIZURU, JAPAN.

Diet of the Mississippi Threadfin Shad, *Dorosoma petenense atchafalaya*, in Arizona¹

WM. L. HASKELL

THE purpose of this paper is to record the principal foods ingested by adult Mississippi threadfin shad, *Dorosoma petenense atchafalaya* (Evermann and Kendall), in lakes of central Arizona where the fish was recently introduced. It is hoped that this effort will provide useful data for future fisheries management and add to the basic knowledge of the species. A thorough search of the literature, published and unpublished, reveals a very recent interest in the life processes and food requirements of this member of the family Clupeidae.

This shad was first introduced into western United States on 16 November 1954 at Lake Havasu, an artificial lake on the lower Colorado River (Kimsey, 1957:1). Subsequent plantings were made in other impoundments up and down the river by both California and Arizona, and the species was also introduced into the deep-water lakes of central Arizona. After each stocking, there occurred what is commonly known as a biological explosion; the species grew and reproduced at a rate that exceeded even the most optimistic hopes of those concerned with discovering a forage fish to shorten and satiate the food chain of the various members of the families Centrarchidae, Salmonidae, and Ictaluridae present in these waters.

ACKNOWLEDGMENTS

Samples were collected at the sites and on the dates listed below through the cooperation of Mr. Dudley Yoder, Chief of Fisheries for the Arizona Game and Fish Department. The assistance and cooperation of Mr. Murl Fox, who operated his electric shocking device under contract to the Department, is also gratefully recognized. Faculty members at Arizona State University giving invaluable aid in identifying organisms, developing techniques, and generally assisting the program were: Dr. Gordon L. Bender, Dr. Ronald R. Clothier, Dr. Hugh Hanson, Dr. Roy M. Johnson, Dr. Chester R. Leathers, Dr. James A. McCleary, and Dr. Herbert L. Stahnke. Also of assistance were fisheries workers from

coast to coast who, too numerous to list here, were valuable contributors of information and encouragement.

METHODS

Threadfin shad were collected when possible during the eight months from 2 December 1957 to 1 August 1958, by means of an electric shocking device. Collecting sites and dates were necessarily limited by the scheduled operation of the shocking device while engaged in routine fisheries work on three artificial lakes in central Arizona. The lakes, their elevations (to the nearest 100 feet) and the dates on which samples were taken from them are as follows: (1) Carl Pleasant, 1600 feet—2 Dec. 1957, 10 Dec. 1957, 17 Dec. 1957, 8 Jan. 1958, 24 Jan. 1958, 10 Feb. 1958; (2) Saguaro, 1500 feet—10 Apr. 1958, 15 Apr. 1958, 24 Apr. 1958, 9 May, 1958; (3) Bartlett, 1700 feet—24 July 1958, 1 Aug. 1958.

Specific data on water levels and fluctuation is available at the Maricopa County Municipal Water Conservation District Number One at Beardsley, Arizona, for Lake Carl Pleasant, and the Salt River Project at 1521 Project Drive, Phoenix, Arizona, for Saguaro and Bartlett Lakes.

These lakes are generally similar in potential depth and size to the extent that each is impounded by a high dam and usually contains many thousands of acre feet of water; but size and depth constantly vary due to considerable water level fluctuation resulting from frequent unscheduled release of water to satisfy irrigation and domestic needs. Water temperatures and degree of organic richness for the three lakes are similar (Mr. Roger Gruenewald, *personal communication*, 1958). Correspondence from Mr. Gruenewald states that records of biological, chemical, and physical tests conducted by him on Carl Pleasant, Saguaro, and Bartlett indicate a comparable organic richness and temperature/depth pattern. He adds that length-weight relationships for largemouth bass (inch classes four inches and up) vary a maximum of only two hundredths of a pound in comparing the three lakes. Thus, food conditions seem comparable for young bass.

From uncounted quantities of collected

¹ This paper is a revision of the original which was accepted by Arizona State University at Tempe, Arizona, on 1 April 1959 in partial fulfillment of the requirements for the Master of Science Degree in the Division of Life Sciences, College of Liberal Arts.

fish killed and fixed in 10:1 formalin on the dates listed, a random sample of 10 individuals was removed from a tub in which the lot for that date was agitated.

A phase contrast microscope equipped with a mechanical stage was employed for counting, identifying, and estimating the volume percent of specific items comprising the total material present in a field. Ten randomly selected fields were read and recorded for each stomach, a total of 100 readings per sample. A magnification of 400 times was used for purposes of identification; counting and estimating are at 100 magnifications. A 10× ocular lens with a Whipple Disk and an ocular micrometer, all calibrated to the 10× and 40× objective lenses, were used for delimiting the fields and portions of fields, and for measuring organisms, respectively. Calibration of the Whipple Disk at 100 magnifications determines the field size to be 1,016,064 microns, or approximately one millimeter.

Counting chamber walls were manually constructed of white petroleum jelly to contain five fluid drops on a glass slide, and enclosed with a cover slip.

Volumetric measurements of stomach contents are readings made after the combined contents of ten stomachs comprising a sample settled 24 hours in a graduated centrifuge tube. Formalin 10:1 was used as the vehicle. This measurement and the average length, weight, and ranges for each sample are introduced in Table 1 to show a lack of correlation in the general size of fish with volume of stomach contents per sample, and to give a volumetric base for other tables and references which are stated in percent of volume and frequency within these sample totals.

Identifications are based upon Smith (1950) for plants and Ward and Whipple (1918) for animalculae.

RESULTS

Estimated percent of total volume and frequency of occurrence of ingested materials are listed in Tables 2 and 3.

The stomach of the threadfin shad is an enlargement of the alimentary tract into a "short, muscular stomach, which resembles the gizzard of a fowl," as stated by Miller (1950) in a discussion of the American clupeid fishes of this genus. A portion of the unidentified organic material observed is probably attributable to the supposed grinding action of this alimentary organ.

TABLE 1
LENGTHS, WEIGHTS, AND STOMACH CONTENT VOLUMES FOR TWELVE THREADFIN SHAD RANDOM SAMPLES (SAMPLE SIZE 10) FROM THREE CENTRAL ARIZONA LAKES DURING PERIOD DEC., 1957, TO AUG., 1958

Date of Sample	Length Range and Mean in mm*	Weight Range and Mean in grams	Stomach Contents Total Volume in ml.
1957			
2 Dec.	97-110 (101.7)	12.7-19.7 (15.99)	0.30
10 Dec.	101-108 (105.3)	14.3-18.3 (16.50)	0.35
17 Dec.	91-128 (109.1)	10.4-32.4 (19.96)	0.15
1958			
8 Jan.	85-103 (94.4)	8.4-15.1 (11.63)	0.25
24 Jan.	92-107 (99.1)	12.6-19.4 (15.44)	0.10
10 Feb.	92-124 (109.1)	11.8-30.1 (20.37)	0.25
10 Apr.	68-110 (97.6)	4.2-21.3 (15.89)	0.25
15 Apr.	89-113 (103.5)	10.7-22.7 (17.90)	0.05
24 Apr.	87-105 (98.5)	11.2-20.0 (16.33)	**
9 May	79-105 (91.1)	7.4-16.5 (12.18)	0.12
24 July	91-111 (101.6)	9.4-17.1 (12.56)	0.37
1 Aug.	97-112 (105.7)	11.6-16.0 (13.68)	0.30

* All length measurements are fork length.

** Volume too small to measure.

The apparent habit of threadfin shad to remain constantly congregated in schools is thought to account for an observed regularity of food types occurring within each sample.

The 100 percent frequency of occurrence and large volume of sand particles, bits of wood, and unidentifiable organic material (partially rotted, digested, or pulverized organic food) tend to indicate that the threadfin shad feeds extensively on the bottom. The better-known closely related gizzard shad, *Dorosoma cepedianum* (LeSueur), is mentioned as a bottom feeder by Jordan (1905:32), Miller (1950:387), Pincher (1948:163), and Viosca (1937:128).

However, the considerable cumulative volume and frequency of occurrence in the threadfin shad stomachs of fresh appearing, intact (as if living when ingested) pelagic phytoplankton suggests that open water feeding is also prevalent through use of the long, fine gill filaments as a strainer. A 100 percent frequency each, and a combined mean estimated percent of total volume of 16.43 for the algal orders of Pennales (Chrysophyta) and Chlorococcales (Chlorophyta) would seem to bear this out. Numerous uniflagellate Chrysomonadales (Chrysophyta) were also encountered intact in the 9 May 1958 sample. Brett (*in* Brown, 1957:123) considered sight to be the dominant sense in seeking out

TABLE 2

ESTIMATED PERCENTAGE OF MATERIALS INGESTED; FROM STOMACH ANALYSIS OF TWELVE RANDOM SAMPLES (SAMPLE SIZE 10) OF THREADFIN SHAD FROM CENTRAL ARIZONA LAKES OVER THE PERIOD 2 DEC. 1957 TO 1 AUG. 1958

	2 Dec. 1957	10 Dec. 1957	17 Dec. 1957	8 Jan. 1958	24 Jan. 1958	10 Feb. 1958	10 Apr. 1958	15 Apr. 1958	24 Apr. 1958	9 May 1958	24 July 1958	1 Aug. 1958	Eleven Sample Mean
<i>Cyanophyta</i>													
Chroococcales	0.2		0.1	0.3	0.4	0.2	0.1	0.5		0.1	0.2	0.1	0.20
Hormogoniales	0.8		0.9	1.8	0.9	0.5				0.1		0.2	0.47
<i>Chlorophyta</i>						1.1						0.4	0.14
Volvocales	0.8	1.0	0.9	2.0	3.0		0.4					0.5	0.78
Tetrasporales					0.5								0.05
Ulotrichales		0.4	0.2				0.5						0.10
Cladophorales											0.1		0.01
Zygnematales	1.0	0.1	1.4	1.2	2.1	1.3	1.6	0.2		0.2	0.1	0.8	0.91
Chlorococcales	19.0	5.5	17.5	21.2	21.2	8.3	17.3	16.8	X	1.2	1.9	0.2	11.83
<i>Euglenophyta</i>													
Euglenales				0.4	0.6		0.2	2.0		0.2	1.5	0.2	0.46
<i>Pyrrophyta</i>													
Dinophyceae	1.7		1.3	0.7	1.7	1.7	1.0	0.1		0.5	0.7	0.3	0.88
<i>Chrysophyta</i>													
Chrysomonadales					1.0	0.2				9.9			1.01
Heterococcales	5.0		2.0	4.0	4.3	2.8							1.64
Pennales	3.1	2.6	5.5	6.5	5.9	5.4	7.2	3.0	X	2.8	7.9	0.7	4.60
Centrales	0.6	0.5	0.7	0.9	0.8	0.7	1.3				0.4		0.54
<i>Protozoa</i>					1.2	0.6	0.7	5.8	X		2.2		0.95
<i>Rotatoria</i>								12.3	X	14.9		8.4	3.24
<i>Nematoda</i>	2.2	3.3	1.6	1.5	2.4	2.2	0.2				0.5	0.6	1.32
<i>Crustacea</i>									X				
Cladocera								1.7		55.0		18.5	6.84
Copepoda											1.2	0.5	0.15
Ostracoda								1.9			1.8	0.9	0.42
<i>Debris</i>													
Wood	14.0	26.0	18.0	7.5	8.0	5.0	5.0	17.0	X	5.0	4.5	3.5	10.32
Sand	40.0	39.0	29.0	35.0	30.0	65.0	30.0	20.0	X	3.0	72.0	60.0	38.45
Unident., organic	11.6	21.6	20.9	17.0	16.0	5.0	34.5	18.7	X	17.1	5.0	4.2	14.69

X Stomachs of the 24 April sample were virtually empty. Flushing of the stomach linings produced traces of the materials indicated by X.

plankton as food by unspecified members of the family Clupeidae.

The profuse variety of organisms found in the stomachs of these samples could result from either or both bottom and pelagic feeding of a usually non-selective nature.

On a basis of common occurrence, the Chroococcales (Cyanophyta), the Zygnematales desmids (Chlorophyta), the dinoflagellates (Pyrrophyta), and the minute aquatic nematodes (Nemathelminthes) are considered to be constant supplements to the seemingly principal foods of greater volumetric occurrence. The sum of 3.31 mean estimated percent of total food volume contributed by these organisms is not a large amount but is notable for its constancy in the diet.

Filamentous algae were infrequent and occurred only in lengths of no more than a very few cells. Their ingestion is considered to be incidental, after filaments have been broken up by some other agent.

The appearance of crustacea and rotifers in the sample for 15 April 1958 from Saguaro Lake, as shown in Tables 2 and 3, may indicate a change in the basic diet of the threadfin shad at this time; but data are inadequate to attribute it specifically to change in sampling area, seasonal change, or other cause. Prior to this time no organisms or parts thereof suggest the presence of crustacea or rotifers in the samples for the year 1958, but excepting the Saguaro Lake sample of 10 April 1958 all prior samples were taken from

TABLE 3

PERCENTAGE FREQUENCY OF OCCURRENCE OF MATERIALS INGESTED BY THREADFIN SHAD IN TWELVE RANDOM SAMPLES (SAMPLE SIZE 10) FROM CENTRAL ARIZONA LAKES IN THE PERIOD 2 DEC. 1957 TO 1 AUG. 1958

	2 Dec. 1957	10 Dec. 1957	17 Dec. 1957	8 Jan. 1958	24 Jan. 1958	10 Feb. 1958	10 Apr. 1958	15 Apr. 1958	24 Apr. 1958	9 May 1958	24 July 1958	1 Aug. 1958	Mean Fre- quency
<i>Cyanophyta</i>													
Chroococcales	30		10	20	10	10	10	20		20	40	20	9
Hormogoniales	20		20	30	20	20				20		100	21
<i>Chlorophyta</i>			10									50	5
Volvocales	60	60	70	60	50		20					30	32
Tetrasporales					20								2
Ulotrichales		40	20				10						6
Cladophorales											10		1
Zygnematales	60	10	50	50	70	60	70	20		20	10	60	44
Chlorococcales	100	100	100	100	100	100	100	100	X	100	100	100	100
<i>Euglenophyta</i>													
Euglenales				10	20		10	30		20	60	50	20
<i>Pyrrophyta</i>													
Dinophyceae	50		50	40	50	60	60	10		50	80	70	47
<i>Chrysophyta</i>													
Chrysomonadales					40	30				100			15
Heterococcales	100		40	70	70	60							31
Pennales	100	100	100	100	100	100	100	100	X	100	100	100	100
Centrales	30	30	40	70	50	80	40				30		34
<i>Protozoa</i>					40	30	60	100	X		80		28
<i>Rotatoria</i>								100	X	100		100	27
<i>Nematoda</i>	70	80	80	80	90	90	20				60	70	58
<i>Crustacea</i>									X				
Cladocera								100		100		90	26
Copepoda											10		1
Ostracoda								100			20	40	15
<i>Debris</i>													
Wood	100	100	100	100	100	100	100	100	X	100	100	100	100
Sand	100	100	100	100	100	100	100	100	X	100	100	100	100
Unident., organic	100	100	100	100	100	100	100	100	X	100	100	100	100

X Stomachs of the 24 April sample were virtually empty. Flushing of the stomach linings produced traces of the materials indicated by X.

Lake Carl Pleasant. Although the amount of crustacea present in the 15 April sample is small, rotifers occur for the first time and are quantitatively noteworthy; there is no obvious decline in algal foods. The next reliable sample, that of 9 May 1958, shows a considerable increase in crustacea (Cladocera) which is accompanied by an abrupt drop in the volume quantity of Chlorococcales. Except for the sample for 24 July 1958 in which rotifers are absent, crustacea and rotifers persist through the last sample taken on 1 August 1958.

Regrettably, the 24 April 1958 sample stomachs were virtually empty. A strong flushing of the dissected stomachs with a stream from a dropper freed traces of the

organisms indicated by "X" in Tables 2 and 3. It is quite possible that these empty stomachs are a direct result of extensive spawning activity by the fish. The time of sampling closely coincides with spawning observations made by Kimsey (1957:3) in Lake Havasu and by Berry, Huish, and Moody (1956:192) in Lake Newnan, Florida. Due to this paucity of organisms no measurements or estimates are recorded for this sample. It is felt that the proportionate abundance of hard parts found in these stomachs probably distorts the true picture for comparative quantities of material ingested.

Considered worthy of note in the 2 December and 10 December 1957 samples from Lake Carl Pleasant were bits of morphologi-

cally unidentifiable material believed to be remains of crustacean shells. Assuming this belief to be correct, a question is posed as to whether the bits of loricae were ingested as part of the rotting organic material consumed in bottom feeding, or whether threadfin shad in this lake continue to feed upon active crustaceans into December. A lone sample taken from the Colorado River by Kimsey (1957:5) on 3 November 1956 indicates a frequency of occurrence for crustacea of 100 percent, and an estimated volume of 52 percent.

After 10 December 1957 no further evidence of crustaceans was observed in samples from Lake Carl Pleasant. On 15 April 1958, crustacea appeared in stomach samples from Saguaro Lake. The data seem to indicate that a substantial period of the year passes without crustaceans in the threadfin shad diet at Lake Carl Pleasant. Although perhaps of no significance, it should be borne in mind that Arizona winters are mild at this elevation, and a freezing air temperature is uncommon prior to January (Smith, 1956:21).

Both Mastigophora and Infusoria are included among the Protozoa. Their comparatively low frequency and volume, and their lack of correlation with the presence or absence of other specific materials, does not merit further consideration at this time.

Nematodes, probably ingested in the course of bottom feeding, constitute a mean of only 1.32 estimated percent of total ingested materials, but a frequency of 58 percent. Tables 2 and 3 indicate their volume and frequency to decrease at the time crustacea and rotifers appear in the diet, but since the decline closely coincides with a change in the body of water being sampled no conclusion is drawn.

Insects, immature and adults, are surprisingly absent in all samples. No explanation is offered, but small unidentified insect forms have been occasionally observed in stomachs from other bodies of water prior to this sampling.

CONCLUSIONS AND SUMMARY

The major items in the diet of adult threadfin shad in Lake Carl Pleasant during the winter months of 1957-1958 were algae, the principal constituents being diatoms and

the unicellular green species. Spring sampling of Saguaro Lake and summer sampling of Bartlett Lake in 1958 show animalculae to be a major food item, the greatest bulk being rotifers and crustaceans. Lesser quantities of the algal forms continue to occur regularly in the spring and summer samples.

Contents of samples suggest that two principal methods of feeding occur. Both apparently utilize the gill filaments as a strainer to segregate material from the water for ingestion. The chief indicated difference between the two is the source of materials; one takes material from the bottom of the body of water whereas the other is a true pelagic plankton-feeding operation taking place at any level where organisms are satisfactorily abundant. The constant presence of fresh-appearing intact pelagic algae in stomachs, and debris consisting of particles of sand and bits of wood, suggests that the threadfin shad consistently engages in both methods.

LITERATURE CITED

- BERRY, FREDERICK H., MELVIN T. HUISE, AND HAROLD MOODY. 1956. Spawning mortality of the threadfin shad *Dorosoma petenense* (Günther), in Florida. *Copeia* 1956(3):192.
- BROWN, M. E. (Editor) 1957. *The Physiology of Fishes*. Vol. 2. Academic Press, Inc., New York. 526 pp.
- JORDAN, DAVID STARR. 1905. *Guide to the Study of Fishes*. Vol. 1. Henry Holt & Co., New York. xxvi + 624 pp.
- KIMSEY, J. BRUCE, ROBERT H. HAGY, AND GEORGE W. MCCAMMON. 1957. Progress report on the Mississippi threadfin shad, *Dorosoma petenense atchafalaya*, in the Colorado River for 1956. Report No. 57-23. Calif. Dept. Fish and Game, Sacramento. 48 pp.
- MILLER, ROBERT RUSH. 1950. A review of the American clupeid fishes of the genus *Dorosoma*. *Bull. U. S. Nat. Mus.* 100:387-410.
- PINCHER, CHAPMAN. 1948. *A Study of Fish*. Duell, Sloan and Pearce, New York. 343 pp.
- SMITH, GILBERT M. 1950. *The Fresh-Water Algae of the United States*. McGraw-Hill Book Co., Inc., New York. 719 pp.
- SMITH, H. V. 1956. The climate of Arizona. *Ariz. Agric. Expt. Sta. Bull.* 279:21.
- VIOSCA, PERCY, JR. 1937. *Pondfish Culture*. Pelican Publishing Co., New Orleans. xxiii + 260 pp.
- WARD, HENRY BALDWIN, AND GEORGE C. WHIPPLE. 1918. *Fresh-Water Biology*. John Wiley & Son, New York. 1111 pp.

DEPARTMENT OF FISH AND GAME MANAGEMENT, OREGON STATE COLLEGE, CORVALLIS, OREGON.

Distribution and Variation in the Glossy Water Snake, *Natrix rigida* (Say)

JAMES E. HUHEEY

NATRIX RIGIDA (Say) is a small, secretive water snake inhabiting the southern United States. Because of its size and habits, it has been considered rare, and its range was long thought to be from South Carolina to Louisiana. Recent collecting has brought new specimens to light, and the recorded range has been extended from Virginia to Texas. It is the purpose of this study to delimit the range and explore the regional variation exhibited by this species. It has been found that the specimens fall into three distinct populations which appear to warrant subspecific recognition.

A total of 255 specimens was examined, including sizable series from most areas of the range. Alabama, western Georgia, and North Carolina are sparsely represented. The following persons and institutions made specimens or data available (initials in parentheses are those used in subsequent references to these specimens): W. Frank Blair, University of Texas (TNHC); W. E. Brode, Gulf Coast Research Laboratory (GCRL); Bryce C. Brown (BCB), Strecker Museum, Baylor University (SM); E. Milby Burton, Charleston Museum (ChM); Fred R. Cagle, Tulane University (TU); Charles C. Carpenter, University of Oklahoma (UOMZ); Doris M. Cochran, United States National Museum (USNM); R. Conant, Academy of Natural Sciences of Philadelphia (ANSP); Fannye A. Cook, Mississippi Game and Fish Commission Museum (MGFCM); Harry T. Davis, Texas Cooperative Wildlife Museum (TCWM); Norman E. Hartweg and Charles F. Walker, University of Michigan Museum of Zoology (UMMZ); Donald F. Hoffmeister, University of Illinois Museum of Natural History (UIMNH); Robert F. Inger, Chicago Natural History Museum (CNHM); John M. Legler, University of Kansas Museum of Natural History (KUMNH); Bernard S. Martof, University of Georgia (UG); Roger Rageot, Norfolk Museum of Arts and Sciences (NMAS); Neil D. Richmond, Carnegie Museum (CM); William J. Riener, University of Florida (UF); Ernest E. Williams, Museum of Comparative Zoology, Harvard (MCZ); Richard G. Zweifel, American Museum of Natural History (AMNH).

In addition to the preceding individuals

and institutions, I thank Miss Alice Boatwright for the drawings; W. Leslie Burger and Roger Rageot for their observations on *N. rigida* in North Carolina; Herndon G. Dowling for information on Arkansas specimens; Roger Conant for examination of the holotype and other assistance; Philip W. Smith for helpful advice and criticism; and especially Hobart M. Smith who suggested and guided this work from its initiation.

Dorsal scale reduction formulae and ventral counts were obtained by the methods of Dowling (1951a and b). All measurements are expressed in millimeters.

No attempt has been made to construct a complete synonymy of all references to this species. However, all name combinations, and references to their original proposals, are cited, and all data that could be found on the natural history were gleaned from the literature. Curiously, no new name other than *rigida* has ever been proposed for this species. Published records which duplicate locality records substantiated by the specimens examined have been generally omitted.

DESCRIPTION OF SPECIES AND SUBSPECIES

Natrix rigida (Say)

Coluber rigidus Say, 1825. *Jour. Acad. Nat. Sci. Phila.* (1), 4:239.

Tropidonotus rigidus Holbrook, 1842. *N. Amer. Herp.* 4:39, pl. 10.

Regina rigida Baird and Girard, 1853. *Cat. N. Amer. Rept.*, p. 46.

Tropidonotus leberis, var. *rigidus* Jan, 1865. *Arch. Zool. Anat. Phys.* 3:230.

Natrix rigida Cope, 1892. *Proc. U. S. Nat. Mus.* 14:668.

Natrix rigida differs from all other North American *Natrix* by having the following combination of characteristics: 1) only 19 dorsal scale rows; 2) first dorsal scale row smooth; 3) nasal single, semi-divided; 4) lateral light stripe confined to first dorsal scale row.

Diagnosis and general description of species.—Ventrals 124–42; caudals 50–71; oculars generally 2–2 (except in one subspecies which has them 1–2); nasal single, semi-divided; labials generally 7 upper, 10 lower; dorsal scale rows 19–17; anal divided; scales keeled

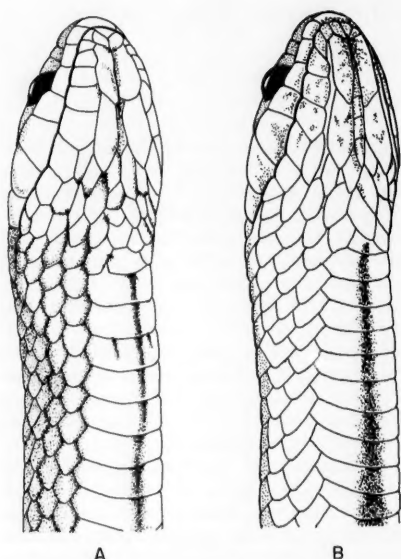


Fig. 1.—Throat pattern in *Natrix rigida*. A. *N. r. rigida*. B. *N. r. deltae*. Note shading on scales of throat which gives appearance of lines in *N. r. rigida*.

except for 1st row. Upper parts olive-brown to brown, two darker stripes sometimes distinguishable on dorsum. Faint lateral line on first scale row. Venter light with two rows of semi-oval or triangular dark spots converging near throat. Usually an irregular dark line formed by shading of median edges of subcaudals.

Three populations are recognizable as subspecies.

Natrix rigida rigida (Say)

Holotype.—ANSP 16795, "the southern states." Assigning the holotype to one of the three populations here recognized is not simple. Say's only statement concerning the type locality was "inhabits the southern states." Schmidt (1951) restricted the type locality to Charleston, South Carolina. For reasons cited below, this restriction is here accepted.

Diagnosis.—Color as described for species. Distinguishable from western subspecies by a pattern of lines formed by shading of the edges of the first few rows of dorsal scales in the vicinity of the lower labials (Fig. 1 A). Ventrals 124–140, mean 132.8 ± 2.8 ; caudals in females 50–59, mean 54.6 ± 2.1 ; caudals in males 57–67, mean 62.7 ± 2.2 ; oculars usually 2–2.

Description of holotype.—Mr. Roger Conant has given me the following data from an examination of the type:

"Scale counts for this specimen (ANSP 16795) are as follows: ventrals 132, subcaudals 52, supralabials 7, infralabials 11, 10, oculars 2–2, temporals 1–2. The scale rows are 19–17 with the 4th row dropping out at a point above the 82nd ventral on the left side of the body and above the 83rd ventral on the right side of the body. The snake is 518 mm. long and has a tail length of 101 mm. I sex it as a female."

"Color much as Say described it except for fading. Say, however, makes no mention of two dark longitudinal stripes down back. Since he mentioned 'Body very dark greenish-brown above' it may be that fading has brought these out. They may not have been discernible in life or when freshly preserved. These begin right behind the head and run together toward the end of the tail. They occupy two rows of scales on each side of the middorsal row, leaving that row and small fractions of the adjacent rows the same shade as the ground color below the dark stripes. Actually the dark stripes are not much darker than the ground color."

Almost all specimens from the Atlantic Coastal Plain differ from the old, and presumably faded, holotype in having a distinct pattern on the throat. This pattern consists of a series of fine lines formed by shading on the edges of the throat scales (see Fig. 1 A). The lack of throat pattern in the holotype may be due to fading or sloughing of the scales. The probability that a specimen from the Gulf Coast population would have a caudal count as low as 52 or lower is calculated to be about 0.01. On the basis of both caudal count and the presence of two preoculars on both sides, the probability of the holotype being found in the New Orleans population is calculated to be 0.02 (0.19×0.10). Accordingly Schmidt's restriction of type locality to Charleston is here upheld and accepted.

Specimens examined.—In the interest of brevity and economy, locality records are listed only by counties. Complete data are available from the author should they be desired. FLORIDA: Alachua Co. UF 1346, 1950; UMMZ 98712; Marion Co. UF 1076; Cross Creek, (?) Marion Co. BCB 4641; Putnam Co. USNM 17389; Volusia Co. UF 4841, 4842.1, 4842.2; GEORGIA: Charlton Co. CM 22079; USNM 130118–9; Chatham Co. CM 27767; USNM 80743; NORTH CAROLINA: New Hanover Co. NCSM 58/7/8; Tyrell Co.

NMA
ley Co
53.22.2
UMM
USNM
18171
Lita
LINA
1954).
Ran
the Ar
Marion
ing su
N
Hol
ferson
W. B.
Dia
from v
late th
count
cauda
cauda
lars 2
Des
male,
cauda
ocular
19 [—
chin
color
Spe
noted
types
ternat
includ
woul
AL
SAS:
Co.
FLOI
GEO:
ANA
0942
TCW
24500
12883
1680:
MISS
55.46
21558
phrey
MGF
Ston
mer
UOM
77656

NMAS 1014; SOUTH CAROLINA: Berkeley Co. Chm 36.74 (82 specs.), 52.143.12(2), 53.22.29, 53.136.2; CM 9391-2; MCZ 81; UMMZ 84433, 105102; Georgetown Co. USNM 1387; VIRGINIA: New Kent Co. CM 18171-2, 18531, 18862-5.

Literature records.—NORTH CAROLINA: Jones Co. (Schwartz and Etheridge, 1954).

Range.—From New Kent Co., Va., along the Atlantic Coastal Plain to Volusia Co. and Marion Co., Fla. Intergrades with the following subspecies in Georgia.

Natrix rigida sinicola, *subsp. nov.*

Holotype.—UIMNH 1159, Beaumont, Jefferson Co., Texas, collected May 2, 1948, by W. B. Robertson.

Diagnosis.—Color similar to *N. r. rigida*, from which it differs by virtue of an immaculate throat (Fig. 1 B) and by a higher caudal count. Ventrals 129–141, mean 134.8 ± 2.1 ; caudals in females 55–64, mean 58.8 ± 2.9 ; caudals in males 61–71, mean 67.6 ± 2.5 ; oculars 2–2.

Description of holotype.—The type is a female, 516 mm. in total length. Ventrals 135; caudals 63; labials, 7 upper, 10/11 lower; oculars 2–2; temporals 2–2. Scale formula: 19 [–4 (80)/–4 (78)] 17 (135). Throat and chin immaculate except for small spot of color on rear of anterior chinshield.

Specimens examined.—Paratypes are denoted by asterisks. It is realized that paratypes are not currently recognized by the International Commission, but they have been included because it was felt that some readers would desire this information.

ALABAMA: Lee Co. CM 9894*; ARKANSAS: Grant Co. UMMZ 109372*; Jefferson Co. CM 24579; Saline Co. CM 24012*; FLORIDA: Escambia Co. UMMZ 84432*; GEORGIA: Taylor Co. MCZ 5706; LOUISIANA: Caddo Par. CNHM 7774*; SM 0941*, 0942*; Caldwell Par. TU 3810; Cameron Par. TCWM 10656*; Natchitoches Par. KUMNH 24500*; Ouachita Par. UOMZ 22794*; TU 12883*, 12912, 12913*; Rapides Par. TU 16804*; Sabine Par. TU 13723, 14109*, 15322; MISSISSIPPI: Forrest Co. GCRL 53.1078*, 55.46*; Harrison Co. AMNH 46755; CNHM 21558*; UMMZ 76764(2), 76765(2); Humphreys Co. UMMZ 86692; Pearl River Co. MGFCM 1651; Simpson Co. GCRL 26.53; Stone Co. TU 17100*; OKLAHOMA: Latimer Co. UOMZ 8068*; Pushmataha Co. UOMZ 1735; TEXAS: Bowie Co. UMMZ 77656*; Chambers Co. BCB 6279*; Cherokee

Co. TNHC 14254*, 19532*; Galveston Co. BCB 5993; Hardin Co. BCB 3784*; CNHM 55394*; TNHC 6360*; Harris Co. UIMNH 21905*; Harrison Co. TNHC 17558*; Henderson Co. BCB 3487-8; UIMNH 16923-6*; Jasper Co. TCWM 1500*; Jefferson Co. BCB 4114, 5146*, 6273, 6515-6*; SM 701-2*, 872*, 874-5*, 876, 877*, 878, 2108, 2109*, 2110-1, 2733-5*; TCWM 12011*; Leon Co. BCB 3511*; TCWM 1499*, 3286-7, 5223, 5224*, 8707, 8708*; Liberty Co. BCB 5268*; UMMZ 116131-2*; Orange Co. TNHC 21935; Smith Co. TNHC 20556.

Literature records.—ALABAMA: Mobile Co., Montgomery Co., (Haltom, 1931); ARKANSAS: Reported from southwestern part of state [inferred as Miller Co.] (Strecker and Williams, 1928); LOUISIANA: Reported from "hill parishes," area bounded by Ouachita River on the east; Catahoula, LaSalle, and Grant parishes on the south; Red River on the west; Arkansas on the north (Clark, 1949); MISSISSIPPI: Jones Co., Stone Co., and Pearl River Co. (Cook, 1943); TEXAS: San Augustine Co., (Brown, 1950).

Range.—From central Georgia where it intergrades with *rigida*, westward through the Gulf Coastal Plain, exclusive of the range of the following subspecies, to eastern Texas and southeastern Oklahoma.

Derivation of name.—From *L. sinus*, gulf or area surrounding a gulf; *L. incola*, an inhabitant.

Natrix rigida deltae, *subsp. nov.*

Holotype.—TU 11969, Paradis, St. Charles Parish, Louisiana.

Diagnosis.—Color and pattern those of *sinicola* from which *deltae* differs appreciably only in scutellation. Characterized by a high incidence of single preoculars, a trend toward higher ventral counts, and a marked difference in caudal counts. Ventrals 132–142, mean 137.3 ± 2.1 ; caudals in females 50–58, mean 54.6 ± 2.0 ; caudals in males 58–69, mean 64.1 ± 3.0 ; oculars usually 1–2.

Description of holotype.—Female 662 mm. in total length, tail 121 mm. Ventrals 135; caudals 52; labials 7 upper, 10 lower; oculars 1–2; temporals 1–2. Scale formula: 19 [–4 (88)/–4 (91)] 17 (135). Dorsal color ends on 1st row at 11th ventral, 2nd row at 8th, 3rd row at 3rd. No pattern on throat; diffuse shading randomly scattered over both upper and lower labials and anterior chin shields. Some diffuse shading between rows of spots on venter.

Specimens examined.—Paratypes are de-

noted by asterisks. LOUISIANA: Jefferson Par. AMNH 68979*; TU 6036*, 7159*, 11827*, 16068*; UMMZ 116130; La Fourche Par. AMNH 57776, 57777-8*; TU 10867*, 11568*, 13752*, 16212*; Orleans Par. TU 6284, 6307, 17296; UMMZ 98668(2); USNM 13040; St. Bernard Par. TU 11339-40; St. Charles Par. TU 6156*, 7154*, 11999*, 12000*, 13614, 13717*, 17262 (11 specs.); St. John the Baptist Par. TU 6289; St. Mary Par. USNM 71180*; St. Tammany Par. AMNH 68980*, 68981; TU 2593, 5504, 6292*; MISSISSIPPI: Hancock Co. TU 6037.

Range.—The Mississippi River Delta at New Orleans. Extends east and north of Lake Pontchartrain a short distance where it intergrades with *sinicola*. Exact western limit not known but about 100 miles west of New Orleans.

Derivation of name.—From the fact that this subspecies inhabits the Mississippi River Delta and surrounding areas.

KEY TO THE SUBSPECIES OF

Natrix rigida

1. Color pattern present on throat (Fig. 1 A)..... *rigida*
Color pattern absent on throat (Fig. 1 B)..... 2
2. Preoculars two on both sides..... 3
Preocular single on at least one side..... *deltæ*
3. Ventrals minus caudals 81 or more, females; 73 or more, males..... *deltæ*
Ventrals minus caudals 80 or less, females; 72 or less, males..... 4
4. Caudals 55 or more, females; 63 or more, males..... *sinicola*
Caudals 54 or less, females; 62 or less, males..... *rigida*

The key could have been constructed more simply, but only with loss of efficiency. In a series of about 200 intact specimens, excluding intergrades, the form of key here adopted was found to be over 90 percent effective in allocating specimens to their proper subspecies with no prior knowledge of their geographical origin.

GEOGRAPHICAL VARIATION

Color and pattern.—The color of *N. rigida* does not appear to vary from one part of its range to another. The major pattern variation is the presence of a throat pattern in *N. r. rigida* and its absence in the western populations. The intensity and extent of this pattern vary; sometimes extending completely

to the labials with dark color on the chin shields as well. Other specimens have the pattern extending only a short distance forward from the edge of the normal dorsal color. This variation seems to be completely independent of provenance of specimens within the range of *N. r. rigida*. Occasional specimens of *sinicola* or *deltæ* exhibit light spotting about the chin shields or, more rarely, a diffuse shading on the lower jaw, but never show the characteristic pattern of *rigida*.

Preoculars.—*N. r. deltæ* may be differentiated from the other subspecies by the high incidence of single preoculars. Only one other series of specimens (from Charleston, South Carolina) even approaches it in this respect. However, if the specimens are divided into two groups on the basis of length, a sharp contrast is revealed between these two populations. In *deltæ* exceeding 250 mm. in total length, the preoculars in 58 percent are single on both sides, 23 percent single on one side, and 19 percent double on both sides; in *deltæ* measuring less than 250 mm. in total length, the preoculars are 58 percent single on both sides, 10 percent single on one side, and 32 percent double on both sides. In contrast, in the Charleston population those exceeding 250 mm. in total length have nine percent single on both sides, nine percent single on one side, 82 percent double on both sides, and at a total length less than 250 mm., 26 percent are single on both sides, 28 percent are single on one side, and 46 percent are double on both sides. Using the chi-square method, one finds that the probability is less than 0.001 that the larger and smaller specimens from Charleston came from the same statistical population with the variation caused by sampling errors alone. It is obvious, therefore, that although both samples certainly came from the same gene pool, the one has been acted upon by rather strong selective pressures. Dunn (1942) has pointed out that the young of a species are often more variable than the adults. It would appear that many of these variations are related to genes which are subvital. However, in the case of *deltæ*, although the data are not especially significant, if selection does occur, it appears to favor a single preocular rather than select against it; it certainly does not favor it in the Charleston population. Accordingly it seems best to base the taxonomic characteristics of these populations on those of the adult, reproducing populations.

New Orleans and Charleston are the only areas from which sufficient specimens, both

F
Lou
Oke
Co.
gini
rept
delt
stan
mod
disc

juven
comp
able
semb
New
Ca
simil
arati
on th
and
latio
How
pare
the
grad
tion
vari
vers
othe
mea
thro
Way
lina
Caro
W
New
west

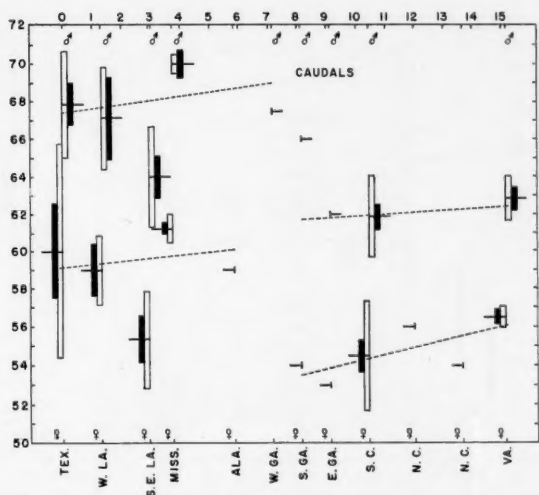


Fig. 2.—Caudals in *Natrix rigida*. Localities, listed from left to right, are: Texas; western Louisiana; New Orleans, Louisiana; Biloxi, Mississippi; Lee Co., Alabama; Taylor Co., Georgia; Okefinokee Swamp, Georgia; Savannah, Georgia; Charleston, South Carolina; New Hanover Co., North Carolina; Tyrell Co., North Carolina; New Kent Co., Virginia. Samples from Virginia to Okefinokee Swamp belong to *N. r. rigida*; those from Taylor Co., Georgia, to Texas represent *N. r. sinicola* except for the population at New Orleans, Louisiana, which is *N. r. deltae*. Data shown are means (horizontal lines), one standard deviation (white bars) and two standard errors of the means (black bars). Broken lines were derived from sample means by a modified method of least squares in order to increase objectivity. (For an exceptionally lucid discussion of the method of least squares, see Daniels, *et al.*, 1956:339.)

juvenile and adult, are available for such a comparison to be made. However, it is probable that the other populations would resemble that of Charleston more than that of New Orleans.

Caudals.—The use of counts of caudals and similar meristic characters for taxonomic separation of subspecies has been justly criticized on the grounds that often clines are involved and the subspecific status of such clinal populations is a matter of individual preference. However, in the case of *Natrix rigida*, apparently no such cline is involved except in the comparatively narrow areas of intergradation. The mean, one standard deviation and two standard errors of the mean of various small populations have been plotted versus their relative distances from one another (Fig. 2). The latter were obtained by measuring along a smooth curve drawn through Leon Co., Texas; Biloxi, Mississippi; Waycross, Georgia; Charleston, South Carolina; New Hanover Co. and Tyrell Co., North Carolina; and New Kent Co., Virginia.

With the exception of the population at New Orleans (*deltae*), the means of the other western populations (*sinicola*) do not vary

appreciably until the area of intergradation (with *rigida*) is reached (Georgia) where a sharp break occurs. This area also corresponds with the disappearance of throat pattern. Thus the two characters coincide and reinforce each other and the difference between the populations is significant.

Ventrals.—Examination of the data on the Atlantic Coast populations reveals the possibility of separation of the specimens into two distinct groups on the basis of ventrals, using 131 as the "break." Specimens from north of Okefinokee Swamp have more than this number, those from Florida have less. However, the "break" can be shown to be associated with a cline (Fig. 3), which shows no evidence of leveling at its southern end. Moreover, no other character which indicates the presence of two taxonomically distinct populations can be found. On the basis of this evidence it is not considered advisable to recognize the Florida population as taxonomically distinct. If a population from southern Florida could be shown to exist with a uniformly low ventral count over an appreciable area, it could then be recognized subspecifically and the specimens from northern

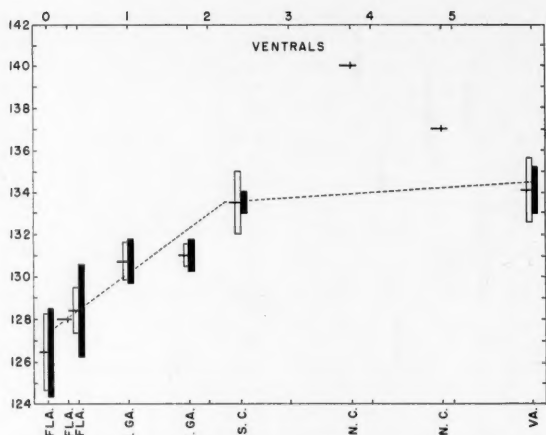


Fig. 3.—Ventrals in *Natrix r. rigida*. Localities, listed from left to right, are: Volusia Co., Florida; Marion Co., Florida; Alachua and Putnam cos., Florida; Okefinokee Swamp, Georgia; Savannah, Georgia; Charleston, South Carolina; New Hanover Co., North Carolina; Tyrell Co., North Carolina; New Kent Co., Virginia. Sexes combined. Data shown are means (horizontal lines), one standard deviation (white bars), and two standard errors of the means (black bars). Broken lines were derived from sample means by a modified method of least squares.

Florida would fall naturally into place as intergrades. Without evidence of such a population, the observed cline can best be interpreted as correlated with adjustments of local populations to environmental conditions that become increasingly adverse southward until a critical limit is reached, beyond which the species apparently cannot range.

INDIVIDUAL VARIATION

Scutellation.—Numbers in parentheses are percentages.

N. r. rigida: Supralabials, six (1.6), seven (80), seven and eight (12), eight (6). Infralabials, nine (3.1), nine and ten (4.6), ten (78), ten and eleven (11), eleven (3.1). Preoculars, one (17), one and two (17), two (64), two and three (2). Postoculars, one (0.9), one and two (3.4), two (75), two and three (16), three (4.3). Scale reduction, 3+4 (2), -4 (72), 4+5 (16), -5 (10); mean point of reduction: females 83, interquartile range 77-93; males 75, interquartile range 71-82.

N. r. sinicola: Supralabials, seven (96), seven and eight (2.4), eight (1.2). Infralabials, nine and ten (3.8), ten (94), eleven (2.5). Preoculars, one (3.5), one and two (2.4), two (93), two and three (1.8). Postoculars, two (73), two and three (15), three (12). Scale reduction, 3+4 (1.3), -4 (94), 4+5 (2.5), -5 (2.5); mean point of reduction: females 86, interquartile range 81-92; males 82, interquartile range 78-89.

Cliburn (1958) has reported on a specimen from Mississippi which has the first three dorsal scale rows smooth.

N. r. deltae: Supralabials, six and seven (3.5), six and eight (3.5), seven (79), seven and eight (10), eight (3.5). Infralabials, nine and ten (7), ten (62), ten and eleven (14), eleven (17). Preoculars, one (58), one and two (17), two (25). Postoculars, two (96), two and three (4). Scale reduction, -4 (100); mean point of reduction: females 93, interquartile range 82-90; males 85, interquartile range 82-90.

Color.—Etheridge (1950) reported on two melanistic individuals in the Tulane collection. Shoop (1959) mentions these and three others in this collection. A specimen from Mississippi (GCRL 54.31) is uniformly dark brown above with no indication of stripes. In place of the two rows of triangular markings on the venter, this specimen has one broad band of very dark brown. The normally light areas on the throat and lateral edges of the ventrals are a somewhat lighter shade of brown than is the dorsum.

GEOGRAPHIC RANGE AND INTERGRADATION

As a whole, the range of *Natrix rigida* follows the Coastal Plain closely (see Fig. 4). It also corresponds more or less to the Austro-riparian biotic province of Dice (1943). In the east, the range probably extends continuously at least as far as Lake Mattamuskeet, North Carolina. Because of the lack of

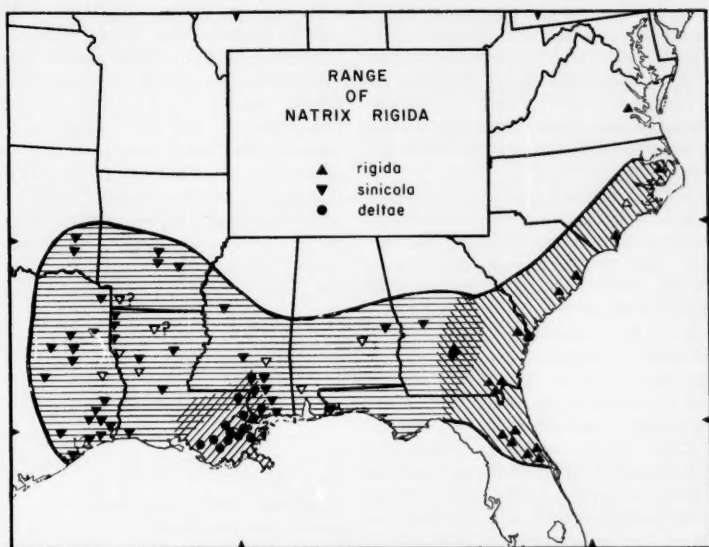


Fig. 4.—Range of *Natrix rigida* showing locality records and ranges of various subspecies. Open symbols denote literature records; combined symbols, intergrades.

specimens from North Carolina, the series of specimens from New Kent Co., Virginia (Richmond, 1940), was considered to be from an isolated population. New specimens from North Carolina have since been reported. In addition to the two specimens examined, the following records are known: Jones Co., ChM 54.44.14 (Schwartz and Etheridge, 1954); Hyde Co., (Burger, *pers. comm.*); Tyrell Co., (Rageot, *pers. comm.*); In view of these records it is likely that the distribution of *rigida* is more or less continuous throughout most of the coastal plain of North Carolina. Burger (*pers. comm.*) has suggested that perhaps the New Kent County population is isolated from those of North Carolina in view of the apparent absence of this and associated species from the vicinity immediately south of New Kent Co., Virginia.

With respect to intergradation between *rigida* and *sinicola*, one specimen from Ben Hill Co., Georgia, (UG 675) is considered an intergrade on the basis of its throat pattern. Unfortunately, part of the tail is missing so the caudal count could not be obtained. Another male specimen (MCZ 5706) from Taylor Co., Georgia, showed no throat pattern and has a high caudal count (67) and has therefore been assigned to *sinicola*. The area of intergradation apparently corresponds to the change from Atlantic Coastal drainage to

that of the Gulf Coast. In a snake as aquatic as *rigida*, this is not surprising. A drainage divide should present a considerable physiographic barrier.

N. r. sinicola extends westward into Texas and Oklahoma as far as the Austroriparian province. In Arkansas it is probably confined to the southeastern portion of the state except for possible invasion up the Arkansas River between the Ozark Plateau and the Ouachita Mountains. It would thus be analogous to *Hyla cinerea* and *Amphiuma means* (Dowling, 1956). The specimen from Latimer Co., Oklahoma, is from the Arkansas River drainage.

The range of *Natrix rigida* apparently does not extend so far north in the Mississippi Valley as one might expect. Several Coastal Plain forms such as *H. cinerea*, *Farancia abacura*, and *Natrix cyclopion* have ranges extending as far northward as southern Illinois. Since the range of *rigida* follows the Austroriparian province so closely in the east, the apparent absence of *rigida* in a large part of the Mississippi Valley is puzzling. A possible cause might be competition from *Natrix grahami*. *N. grahami*, *septemvittata*, and *rigida* appear to belong to an Artenkreis of snakes with roughly similar food requirements. Hairston (1951) has shown that in salamanders, interspecific competition may

be a factor involved in the absence of a species from otherwise suitable habitat. The sympatry of *rigida* with both *grahami* and *septemvittata* over small parts of their respective ranges may reflect areas of competition in which each species is restricted to the habitat most favorable to it with neither species predominating.

The following *deltae* X *sinicola* intergrades have been so designated on the basis of preoculars and caudal counts: Washington Par., Louisiana, TU 12448; Lamar Co., Mississippi, GCRL 56.15, 57.526; Hancock Co., Mississippi, GCRL 55.242, 54.31. A specimen from Hancock Co., Mississippi-Louisiana border, (TU 6037) is tentatively assigned to *deltae* on the basis of single preoculars but may belong to an intergrading population. Likewise a specimen from Simpson Co., Mississippi (GCRL 26.53), although exhibiting single preoculars, is tentatively assigned to *sinicola* until further specimens reveal the exact extent of intergradation. The westernmost specimen of *deltae* is from St. Mary Par., Louisiana, and shows no signs of intergradation with *sinicola*. The nearest specimens of *sinicola* are from Cameron Par. and Rapides Par. and neither of them shows signs of intergradation.

NATURAL HISTORY

Reproduction and growth.—No attempt was made to examine all specimens for eggs or embryos. A specimen which had been collected May 28, 1955, in Rapides Par., Louisiana, measured 529 mm. total length and contained 9 eggs. Another, collected June 29, 1953, in Cameron Par., Louisiana, measured 660 mm. and contained fourteen eggs. A brood of eleven young was examined, but no data other than the "date" (June 2, 1957) are available.

The smallest specimens examined were two females, each 174 mm., and a male 179 mm. in total length. The largest specimen examined was a female from Louisiana, which measured 780 mm. Another, a female from North Carolina, measured 776 mm. The largest male examined was from Louisiana and measured 664 mm. The following size distribution was found: Females, 15 percent larger than 600 mm.; 34 percent larger than 500 mm.; 50 percent larger than 400 mm.; 67 percent larger than 300 mm. and 88 percent larger than 200 mm.; Males, less than one percent larger than 600 mm., 13 percent larger than 500 mm., 30 percent larger than

400 mm., 56 percent larger than 300 mm., and 88 percent larger than 200 mm.

Food.—Strecker (1926) stated that *rigida* "feeds largely on small sirens and fish." Clark (1949) listed seven fish, five *Rana pipiens*, two *Acris* sp., and two crayfish in 18 specimens. Cook (1943) has reported that a specimen was captured while in the process of attempting to swallow a large crayfish. Schwartz and Etheridge (1954) noted crayfish remains in the excrement of a specimen. Rageot (*pers. comm.*) reports that a specimen from Tyrell Co., North Carolina, contained a crayfish. It may well be that crayfish form a larger portion of the diet of this snake than has hitherto been supposed.

SUMMARY

Two hundred and fifty-five specimens of *Natrix rigida* from all parts of its range have been examined for variation. On the basis of pattern and scutellation, two new subspecies are described: *N. r. deltae* from the Mississippi River Delta region, and *N. r. sinicola* from the remainder of the Gulf Coastal Plain. The nominate subspecies, *N. r. rigida*, inhabiting the Atlantic Coastal Plain, contains a population in northern Florida which differs appreciably from neighboring populations, but the variation is shown to be of a clinal nature and thus not worthy of taxonomic recognition. An interesting example of intense selection against the occurrence of single preoculars is shown to exist in the Charleston, South Carolina, population.

LITERATURE CITED

- BROWN, B. C. 1950. Annotated check list of the reptiles and amphibians of Texas. *Baylor Univ. Press, Waco, Texas*. 257 pp.
- CLARK, R. F. 1949. Snakes of the hill parishes of Louisiana. *Jour. Tenn. Acad. Sci.* 24:244-261.
- CLIBURN, J. W. 1958. Notes on some snakes from Mississippi. *Amer. Midl. Nat.* 60:196-201.
- COOK, F. A. 1943. Snakes of Mississippi. *Mississippi Game and Fish Commission, Jackson, Mississippi*. 73 pp.
- DANIELS, F., J. A. MATHEWS, J. W. WILLIAMS, P. BENDER AND R. A. ALBERTY. 1956. Experimental physical chemistry. *McGraw-Hill Book Company, Inc., New York*. xi + 482 pp.
- DELLINGER, D. C., AND J. D. BLACK. 1938. Herpetology of Arkansas. Part One: The Reptiles. *Occas. Pap. Univ. Ark. Mus. No. 1*. 47 pp.
- DICE, L. R. 1943. The biotic provinces of North America. *Univ. Mich. Press, Ann Arbor*. viii + 78 pp.
- DOWLING, H. G. 1951a. A proposed method of expressing scale reduction in snakes. *Copeia* 1951(2):131-134.

coun
1:97
ian
err
DUNN,
char
ETHER
snak
Cope
HAIR
tion
cal
the
HALT
bam
RICH
Virg

P
lo
terna
seriou
that
Atsat
Funct
are p
from
tion
Intu
phibi
been
inclu
amph
prese
posit
tors
meser
repre
Th
tion
part
techn
missi
aid i

In
ultra

- . 1951b. A proposed standard system of counting ventrals in snakes. *Brit. Jour. Herp.* 1:97-99.
- . 1956. Geographic relationships of Ozarkian amphibians and reptiles. *The Southwestern Nat.* 1(4):174-189.
- DUNN, E. R. 1942. Survival value of varietal characters in snakes. *Amer. Nat.* 76:104-109.
- ETHERIDGE, R. E. 1950. Color variants in snakes from the southeastern United States. *Copeia* 1950(4):321.
- HAIRSTON, N. G. 1951. Interspecies competition and its probable influence upon the vertical distribution of Appalachian salamanders of the genus *Plethodon*. *Ecology* 32(2):266-274.
- HALTOM, W. L. 1931. Alabama reptiles. *Alabama Mus. Nat. Hist., Paper No. 11*. 145 pp.
- RICHMOND, N. D. 1940. *Natrix rigida* (Say) in Virginia. *Herpetologica* 2:21.
- SCHMIDT, K. P. 1955. Checklist of North American amphibians and reptiles, Sixth Edition. *Amer. Soc. Ich. and Herp.* viii + 280 pp.
- SCHWARTZ, A., AND R. E. ETHERIDGE. 1954. New and additional herpetological records from the North Carolina Coastal Plain. *Herpetologica* 10:167-171.
- SHOOP, C. R. 1959. Additional melanistic specimens of *Natrix rigida*. *Herpetologica* 15: 160.
- STRECKER, J. K. 1926. On the habits of southern snakes. *Contrib. Baylor Univ. Mus.* 4:1-11.
- STRECKER, J. K., AND W. J. WILLIAMS. 1928. Field notes on the herpetology of Bowie Co., Texas. *Contrib. Baylor Univ. Mus.* 17:1-19.

MUSEUM OF NATURAL HISTORY AND DEPARTMENT OF ZOOLOGY, UNIVERSITY OF ILLINOIS, URBANA, ILLINOIS

Internal Pigmentation and Ultraviolet Transmission of the Integument in Amphibians and Reptiles

DON HUNSAKER II AND CLIFFORD JOHNSON

INTRODUCTION

PIGMENTATION and its function have long been of interest to zoologists. External pigment and color changes were first seriously considered by Aristotle and since that time, by many other authors including Atsatt, 1939; Fox, 1953; and Parker, 1948. Functions proposed by various investigators are protection from predators, protection from injurious rays of the sun and/or absorption and dissipation of heat.

Internal pigmentation of reptiles and amphibians has been noted, but little work has been done on this subject. The present work includes a survey of some North American amphibians and reptiles in regard to the presence or absence of internal melanin deposits. It also includes the transmission factors of ultraviolet light by these pigmented mesenteries, and the integument of some representatives of these groups.

The authors wish to express their appreciation to Dr. H. P. Hanson of the Physics Department, The University of Texas, for his technical assistance in the ultraviolet transmission work, and to Dr. W. F. Blair for his aid in the preparation of this manuscript.

METHODS

In order to ascertain the transmission of ultraviolet light by various tissues, samples

were placed in front of a compact type xenon arc. The photons transmitted through the material energized a Geiger counter, Mark I, Model 3X, manufactured by the Radiation Counter Laboratories. The colloidal graphite was removed from a 3.2-type window on the counter to increase the sensitivity to approximately 3,100 angstroms. The light source emitted a minimum wave length of 1,875 Å which were also counted by the apparatus. The counter was not sensitive to any visual wave lengths. The pulsations of the Geiger counter were recorded on a Mark 13, Model 1, 512 scaler (Radiation Counter Laboratories). These values were read directly from the scaler and are hereafter referred to as "ultraviolet factors." The data presented in this paper are for five minute exposures with 1,730 volts input on the scaler.

Tissue samples were placed over an aluminum plate with 7-mm. diameter aperture to allow the light to pass through. Representative reptiles and amphibians were dissected to determine the presence or absence of internal melanophores.

In no adult anuran forms available does the peritoneum contain a complete complement of melanophores forming the jet black lining seen in certain adult lizards. Only adult male *Anura* have been investigated except in *Acris crepitans*, unless otherwise

TABLE 1

Source	Ultraviolet factor
Artificial light source	628.90
Sunlight, direct	16.42
Sunlight, blocked by clouds	6.34
Skylight	4.61
Under brush cover	2.94
Outdoor background	3.08
Indoor background	0.54

stated. A series of five to 67 individuals were examined for each form of amphibian listed.

Lizards investigated included both sexes. The majority of species contained enough pigmentation to have a black peritoneal lining. No species was found to have an intermediate amount of pigment.

RESULTS

Table 1 presents the comparative data for the wave lengths involved in sunlight and the light source used in the laboratory. The readings of direct sunlight were recorded on July 8, at 2 P.M.

Table 2 indicates the values of ultraviolet light transmitted by the integument and internal pigmented membranes of various reptiles and amphibians. The material in most cases was removed from the live animal and kept moist with Ringer's solution while the experiments were in progress. As the tissue dries out, the transmission increases. No apparent differences in live and preserved skin were detected.

TABLE 2

Tissue	Factor
Skin— <i>Sceloporus cyanogenys</i> , live with scales toward light source	.52
Skin— <i>Sceloporus cyanogenys</i> , live, with scales away from light source	.64
Pigment membrane— <i>Sceloporus cyanogenys</i>	.57
Skin— <i>Eumeces obsoletus</i> , live, scales toward light source	.52
Skin— <i>Eumeces obsoletus</i> , live, with scales away from light source	.59
Skin— <i>Rana catesbeiana</i> tadpole from tail	3.19
Skin— <i>Rana catesbeiana</i> tadpole from dorsal surface—no pigment	.59
Skin— <i>Rana catesbeiana</i> tadpole from dorsal surface, with pigment	.58
Skin— <i>Typhlomolge rathbuni</i> from skull	.83
Skin— <i>Typhlomolge rathbuni</i> dorsolateral skin	.64
Skin— <i>Eurycea notenes</i> dorsal skin and pigment	.68
Background	.54 to .67

The distribution of internal melanophores in the Anura has been found to vary in pattern and intensity between species. The adult distribution has two major patterns of variation:

- (1) The melanophores in the peritoneum vary between the presence and/or absence of an anterior-posterior lateral band of melanophores approximately at the junction of the *rectus abdominis* and *transversus* muscles. These vary in the presence or absence of scattered melanophores above this band.
- (2) The males either have distinctly pigmented or non-pigmented testes.

The most complete data are available for the Hylidae. The larvae of *Pseudacris streckeri*, *P. clarki*, *P. nigrita*, *Hyla crucifer*, and *H. versicolor* possess a melanophore covering within the peritoneum which forms a complete black lining of the coelom. The mid-ventral region remains clear. The ontogeny in respect to internal melanophores has been followed closely with *H. versicolor*. As soon as the hind legs are well-developed, the solid melanophore distribution begins to break up and the gradual thinning out of melanophores continues until the 20-30 mm. stage after metamorphosis is reached, at which time the adult pigmentation condition is attained. In the Ranidae, *Rana pipiens* and *R. catesbeiana* show approximately the same sequence, with the black lining of the larval peritoneum lost, and replaced by the adult pattern prior to sexual maturity. This situation suggests a possible caenogenetic function of the peritoneal melanophores for these forms. Only *A. crepitans* has been examined in newly metamorphosed individuals among those forms showing pigmented testes. Here the pigment was evident by the time the testes became macroscopically visible. The above anuran larvae have been observed repeatedly to frequent shallow open areas and are perhaps exposed to radiation more consistently than adults. The adult pattern appears to be consistent, and pronounced differences exist between certain species which should provide a helpful taxonomic tool.

Within the Hylidae the following forms examined have pigmented testes: *Acris crepitans*, *Pseudacris streckeri*, *P. ornata*, *P. clarki*, *P. nigrita*, *Hyla crucifer*, *H. regilla*, and *Hyla ocularis*. The following have non-pigmented testes: *Hyla squirella*, *H. cinerea*, *H. versicolor*, *H. femoralis*, *H. arenicolor*, *H. wrightorum*, and *H. andersoni*.

Pseudacris ornata is readily distinguished

from *P. streckeri* by the heavy concentration of melanophores dorsal to the anterior-posterior lateral melanophore band. *P. streckeri* is devoid of melanophores above the band and has a few limited to the middorsal region. *P. clarki* has a heavier concentration dorsal to the band than does *P. nigrita*. *Hyla ocularis* has apparently no melanophores within the body cavity other than on the testes. *Hyla crucifer* and *H. regilla* show only a few melanophores about the middorsal region in addition to those on the testes.

Acris crepitans shows a distinct sexual dimorphism. The male has only middorsal melanophores other than on the testes while the female has a relatively heavy concentration extending laterally around the body wall and there is a concentration of pigment on the oviducts.

Hyla versicolor possesses the anterior-posterior lateral band and a scattering of melanophores dorsally, with a concentration in the middorsal coelom. No sexual dimorphism is evident. *H. femoralis* and *H. arenicolor* are similar in having only a few middorsal melanophores and no lateral band. *H. squirella*, *H. cinerea* and *H. wrightorum* show the same general pattern.

Of the Microhylidae, *Microhyla carolinensis*, *M. olivacea*, and *Hypopachus cuneus* are separable on the basis of peritoneal melanophores. The testes are all non-pigmented. *M. olivacea* has a heavy scattering of melanophores throughout the lateral and dorsal coelom while *M. carolinensis* has practically no pigment except in the middorsal coelom. *Hypopachus cuneus* is approximately intermediate, with occasional isolated melanophores in the posterior and middorsal coelom.

In the Leptodactylidae, *Eleutherodactylus latrans* has a weak anterior-posterior lateral pigment band. *Syrrophus marnocki* shows no internal melanophores.

In the Ranidae two groups appear to exist, those with the anterior-posterior lateral band and those without it. The testes are all clear of pigment. Forms with the lateral melanophore band include *Rana pipiens*, *R. palustris*, *R. clamitans*, *R. tarahumarae*, *R. grylio*, *R. sevosa*, and *R. catesbeiana*.

Rana pipiens differs noticeably from *R. palustris* in that the latter has a thick scattering of melanophores throughout the lateral dorsal coelom. *Rana pipiens* shows only an occasional melanophore and no concentrations. The lateral band in both extend only into the anterior one-third of the coe-

lom. *Rana catesbeiana* is similar to *R. palustris*.

Rana tarahumarae has a weak lateral pigment band and a middorsal concentration. *Rana clamitans* shows only an anterior suggestion of the lateral band and no melanophore concentration. *Rana sevosa* and *R. grylio* are similar in possessing well-defined lateral pigment bands and middorsal concentrations. Forms without the lateral band include *Rana areolata* and *R. capito*. Scattered melanophores occur in both and a middorsal concentration characterizes *R. areolata*.

Several salamanders were dissected to ascertain the extent of pigmentation. *Ambystoma tigrinum*, *Diemictylus viridescens*, *Taricha granulosa*, *Taricha rivularis*, and *Aneides lugubris* are characterized by dorsal melanophores on the peritoneum. *Dicamptodon ensatus* has a series of lateral melanophores on the peritoneum, and *Plethodon dunni* has spots of pigment scattered over the entire peritoneum. Salamanders lacking peritoneal pigment include *Typhlomolge rathbuni*, *Siren intermedia*, *Necturus maculosus*, and *Plethodon glutinosus*. No evidence of gonadal pigmentation was observed in these species.

Lizards investigated and found to have a black peritoneum include: *Anolis carolinensis*, *Dipsosaurus dorsalis*, *Crotaphytus collaris*, *C. reticulatus*, *C. wislizenii*, *Sauromalus obesus*, *Callisaurus draconoides*, *Uma notata*, *Holbrookia maculata*, *H. propinqua*, *H. texana*, *Sceloporus variabilis*, *S. grammicus*, *S. jarrovi*, *S. poinsetti*, *S. cynogenys*, *S. olivaceus*, *S. clarki*, *S. magister*, *S. ornatus*, *S. mucronatus*, *S. formosus*, *S. graciosus*, *S. undulatus*, *S. occidentalis*, *S. woodi*, *Uta ornata*, *U. stansburiana*, *Phrynosoma cornutum*, *P. m'calli*, *P. modestum*, *P. plathyrrhinos*, *P. blainvillei*, *Ophisaurus ventralis*, *O. attenuatus*, *Gerrhonotus coeruleus*, *G. kingi*, *G. multicarinatus*, *G. liocephalus*, *Heloderma suspectum*, *Xantusia arizonae*, *X. vigilis*, and *Lygosoma laterale*, also the rhynchocephalian, *Sphenodon punctatus*.

Those which are characterized by the lack of internal pigmentation are: *Coleonyx variegatus*, *Gecko vittatus*, *Anniella pulchra*, *Xantusia henshawi*, *Cnemidophorus tessellatus*, *C. sacki*, *C. sexlineatus*, *C. perplexus*, *C. grahami*, *Eumeces fasciatus*, *E. laticeps*, *E. inexpectatus*, *E. brevilineatus*, *E. tetragrammus*, *E. obsoletus*, *E. multivirgatus*, *E. anthracinus*, *E. septentrionalis*, *E. skiltonianus*, and *E. gilberti*.

Klauber (1939) stated "Pigmented membranes are absent in most of our southwestern desert snakes, being somewhat in evidence posteriorly in the two forms which have the largest proportion of daylight activity, *Coleuber flagellum frenatum* and *Salvadora grahamiae*."

DISCUSSION

The injurious effects of ultraviolet irradiation are well known. Rusch (1941) pointed out the carcinogenic wave lengths for skin tumors in rats lie between 2,900 and 3,341 angstroms. Butler (1955) found that irradiation of urodele limbs results in regression of the limb and/or the induction of an accessory limb structure at the point irradiated. Blum (1950) stated that ultraviolet radiation cyclotizes and slows the time of cleavage in sea urchin eggs. Sea urchin sperm are unable to recover from radiation although fertilization may be effected by an irradiated sperm. Indications are that the cytoplasm of the egg is responsible for any recovery.

These experiments involved high intensity ultraviolet light sources of concentrations not achieved in nature. As is evident in Table 2, the transmission factors of the majority of tissues permit them to absorb these shorter ultraviolet wave lengths and do not allow penetration to the muscle layers. The only significant tissue transmission occurred in *Rana catesbeiana* tadpole skin from the tail. This tissue included the center portion which was 2 mm. in thickness. The ultraviolet factor of 3.19 shows this tissue transmits some ultraviolet. Since the tail is absorbed in metamorphosis, and there are no vital organs inside to protect, this transmission would probably not have any important effect on the organism. It is evident from these results that internal pigmentation does not function as a shield against ultraviolet radiation from sunlight in the 1,875 to 3,100 angstrom range.

Hasselbalch (1911) found the transmission factor of light at 2,840 Å through 1 mm. of human skin to be .01; the factor at 2,980 Å was 2.0; at 3,020 Å it was 8.0 and so on up to 4,360 Å when 59.0 was the factor. From these results, one would expect ultraviolet wave lengths of 3,500 to 4,000 Å to penetrate slightly deeper, but not to the extent that a layer of pigment would be necessary to shield the internal organs.

Kruger (1929) demonstrated that the pigments of reptiles and amphibians effectively filter some long wave length radiation. Lau-

rens (1933) stated that infra-red in sunlight penetrates human skin and muscle 2 to 3 cm. and produces a marked increase in temperature.

The function of the presence or absence of the pigment in the mesenteries is unknown. It could serve in the regulation of body temperatures of the animals involved. The lack of internal pigmentation in *Eumeces* may be explained because the genus has its center of distribution in the forested southeastern United States. The other North American genera are centered in the southwestern United States or Mexico. Fitch (1956) stated *Eumeces fasciatus* has been active during spring days when the night temperatures were sub-freezing. His observations indicate that this lizard emerges earlier in the year than any other species considered in his study.

The western genus *Cnemidophorus* lacks black peritoneal mesenteries. These lizards generally do not remain long in direct sunlight, but hunt by short forays into the sunlight, returning quickly to a cooler environment. This type of behavior would indicate that these lizards' body temperatures are near the critical level. Fitch (1956) substantiated this when he noted that *Cnemidophorus sexlineatus* maintain the highest body temperature (39° to 40°C.) of a group of nineteen reptiles studied. He also mentioned that this species requires the most warmth of those studied.

Coleonyx and *Xantusia* are nocturnal lizards which do not have pigmented mesenteries.

SUMMARY

The relative transmission of ultraviolet light by the skin and pigmented peritoneum of some lizards and salamanders was tested. It was found that the outer integument of these lizards and amphibians effectively eliminated the ultraviolet wave lengths from 1,875 to 3,100 Å. Even the non-pigmented skin of *Typhlomolge rathbuni*, a cave salamander, proved to be opaque to this light.

A survey was made of North American reptiles. Only five genera of lizards lack a pigmented peritoneum in some of its species, *Coleonyx*, *Anniella*, *Cnemidophorus*, *Eumeces*, and *Xantusia*. One species of *Xantusia* has well-developed peritoneal melanophores. A pigmented internal body wall is characteristic of some diurnal snakes of the southwestern United States. Salamanders have both pigmented and non-pigmented peritonea.

Anura
groups
mented

It ap
not fu
violet

ATSATT
by t
deser
Calif
BLUM,
1950,
X-ra
and
Sci. 3
BUTLER
erati
ing
Inst.
FITCH,
in fr
easte
Hist

Th

TH
by
know
has ac
logica
water
gardin
phibi
actual
tested
reas h
ous B
tion o
salini
regar
fluctu
In
tion o
ter h
mine
habit
habit
well
made

Anurans can be separated into two distinct groups by the presence or absence of pigmented testes.

It appears that internal pigmentation does not function as a protection against ultraviolet radiation of the shorter wave lengths.

LITERATURE CITED

- ATSATT, S. R. 1939. Color changes as controlled by temperature and light in the lizards of desert regions of southern California. *Univ. Calif. Los Angeles Publ. Biol. Sci.* 11:237-76.
- BLUM, H. F., J. C. ROBINSON AND G. M. LOOS. 1950. The loci of action of ultraviolet and X-radiation, and of photorecovery in the eggs and sperm of the sea urchin. *Proc. Nat. Acad. Sci.* 36(11):623-7.
- BUTLER, E. G., AND H. F. BLUM. 1955. Regenerative growth in the urodele forelimb following ultraviolet radiation. *Jour. Nat. Cancer Inst.* 15(4):877-88.
- FITCH, HENRY S. 1956. Temperature responses in free-living amphibians and reptiles of north-eastern Kansas. *Univ. Kansas Publ. Mus. Nat. Hist.* 8(7):417-76.
- FOX, DENIS L. 1953. Animal Biochromes and structural colours. *Cambridge Press, London.* xiv + 339 pp.
- HASSELBALCH, K. A., AND J. LINDHARD. 1911. Analyse des Höhenklimas in seinen wirkungen auf die respiration. *Skan. Arch. Physiol.* 25:361-408.
- KLAUBER, L. M. 1939. Studies of reptile life in the arid Southwest. *Bull. Zool. Soc. San Diego* 14:1-100.
- KRUGER, P. 1929. Über die Bedeutung der ultraviolet strahlen für den warmehaushalt der Poikilothermen. *Biol. Zbl.* 49:65-82.
- LAURENS, HENRY. 1933. The physiological effects of radiant energy. *The Chemical Catalog Co., New York.* 610 pp.
- PARKER, G. H. 1948. Animal colour changes and their neurohumors. *Cambridge Press, London.* 377 pp.
- RUSCH, H. P., B. E. KLINE, AND C. A. BAUMANN. 1941. Carcinogenesis by ultraviolet rays with reference to wave length and energy. *Arch. Path.* 31:135-46.

DEPARTMENT OF ZOOLOGY, THE UNIVERSITY OF TEXAS, AUSTIN, TEXAS.

The Ecology of a Brackish Water Population of *Rana pipiens*

RODOLFO RUBAL

INTRODUCTION

THE lack of tolerance of amphibians to brackish or marine water is common knowledge. However, remarkably little work has actually been done to determine the ecological relation of amphibians to brackish water. Most of the published information regarding the brackish water ecology of amphibians is of a cursory nature. Usually the actual salinity of the water has not been tested (i.e., Storer, 1925, regarding *Bufo boreas halophilus*, Hardy, 1943, regarding various British amphibia) or at most the association of a given species of anuran with a given salinity is listed with little or no information regarding breeding conditions or salinity fluctuations (Pearse, 1936, 1911; Brues 1932).

In this paper the relationship of a population of frogs, *Rana pipiens*, to a brackish water habitat is described. An attempt to determine the fluctuations in the salinity of the habitat, the distribution of the animals in the habitat, and the tolerance of the adults as well as eggs to the various salinities has been made.

METHODS

The determinations of the salinities of the water samples were done with the use of a conductivity bridge. The resistance (ohms) of various known concentrations of KCl as well as of various concentrations of Ringer's solution was determined at a given temperature (24°C) and plotted as a simple curve. The resistance of the test samples was then determined and the concentration in parts per thousand (0/00) read from the plotted curve to ± 0.2 0/00. A part of the error inherent in the method is due to the different types of ions involved in the test samples and the known samples (KCl and Ringer's solution) used to determine the curve. However, considering the level of accuracy required for this study the error is insignificant. The water samples were obtained in clean screwcap vials in the field and the determinations of salinity were made in the laboratory.

Eggs were obtained by the standard pituitary gland injections and inseminated in the laboratory. The eggs were tested in different concentrations made by diluting water from

the test site or using various concentrations of Ringer's solution. Parallel tests of eggs in equivalent concentrations of Ringer's solution and water from San Felipe Creek yielded identical results in regard to tolerance values and types of abnormalities produced in the embryos.

The eggs were placed in bowls containing the various test concentrations, about 30 eggs in each bowl, and two bowls were run at each concentration tested. Bowls with concentrations of less than 1 0/00 were always run as controls. A concentration was considered lethal if more than 50% of the embryos died by Stages 23 or 24 (Shumway, 1940). Fortunately, at the higher concentrations mortality was usually 100% and consequently the lethal concentrations were easily and clearly determined. The tests were run at a controlled temperature that fluctuated from 19°C to 20°C.

Frogs for the experiments were collected at Harper's Well Wash and Carrizo Creek (Fig. 1). Commercial dealers supplied frogs from the Lake Champlain region in Vermont and from "Wisconsin." The "Wisconsin" frogs have no exact locality data and may have come from North Dakota or any of the other states in the northern portion of the Great Plains region of the central United States.

LOCALITY

The site of this study is San Felipe Creek, Imperial County, California (see Fig. 1). This is a permanent, saline stream, about 10 miles long, draining into the west side of the Salton Sea (a saline lake having a salinity equal to that of sea water). The stream arises from a number of seepages that emerge on the surface of the desert along the length of the stream. The main channel of San Felipe Creek is a slow-flowing, shallow stream usually a foot or two wide. At certain spots along the stream the water is backed up to form large shallow pools. West of the surface water San Felipe Creek is represented by a dry wash. This dry stream bed extends westward into the mountains and in the area of Sentenac Canyon water is again on the surface, draining into Sentenac Canyon from east of the Volcan Mountains in San Diego County. One of the seepages that drains water into San Felipe Creek is located in Carrizo Creek (see map). The elevation of the area under study is below sea level. At Harper's Well Wash the elevation is approximately 125 feet below sea level. The vegetation along the edges of the stream consists of cattails (*Typha*), sedges, reed (*Phragmites*), and the introduced tamarish (*Tamarix*). The higher ground away from the water of the stream has the typical lower Sonoran vegetation of

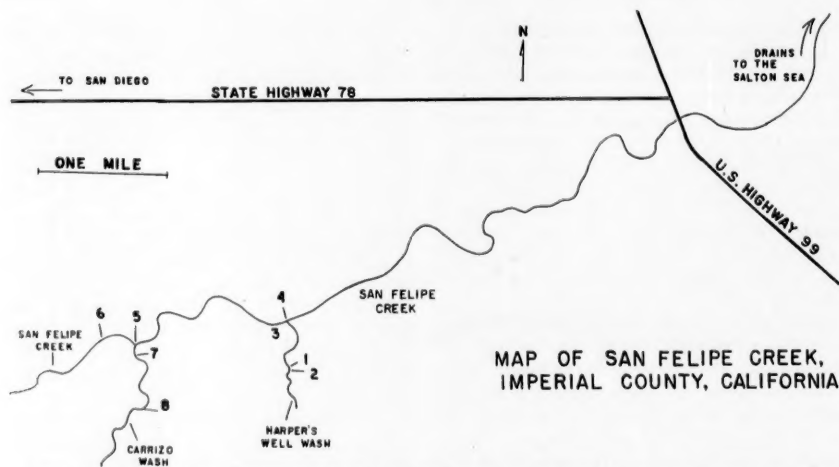


Fig. 1.—A map of San Felipe Creek west of the Salton Sea, Imperial County, California. The numbers on the map correspond to the various stations at which salinity determinations of the water were made. Two of the stations sampled are off the area of the map: Station 9, the westernmost pool of water in San Felipe Creek and Station 10 at Kane Springs, an isolated seepage to the east of the area mapped.

creosote bush (*Larrea*) and mesquite (*Prosopis*). Besides *Rana pipiens* the only other amphibians collected in the study area were *Bufo woodhousei* and *Hyla regilla*.

RESULTS

Water salinities.—The station numbers are plotted on the map (Fig. 1) and the salinity values of four of the stations are plotted against the date of collection in Figure 2. A glance at Figure 2 readily shows that there were marked fluctuations in the salinity of some stations during the two years of testing. Similarly, it will be noticed that there are large differences in the salinity values between the different stations. Thus Station 1 in Harper's Well Wash is characterized by a consistent low salinity value (ranging between 1.75 0/00 and 2.75 0/00) while the main stream (Station 4) of San Felipe Creek is characterized by a much higher salt content (ranging between 6.0 0/00 and 9.0 0/00). Station 3 achieved salinity values approximating sea water (sea water = 35 0/00). Station 3 showed an extreme fluctuation, ranging from 2 0/00 to 30 0/00. In the six stations not plotted in Fig. 2 the salinity ranged from 2.5 0/00 to 34 0/00. The variations in salinity at a given station and between stations can in some instances be explained. Thus Station 3, an isolated pool, achieved a high concentration due to evaporation. The sudden drop in concentration in the sample obtained on XII-57 was the result of a flash flood. However, the cause of some of the fluctuations is not apparent.

Distribution of frogs.—The salinities at which adult frogs have been encountered along San Felipe Creek, Harper's Well Wash, and Carrizo Creek, range from 1.75 0/00 to a maximum of 9.0 0/00. The initiation of breeding has been observed three times, in January 1957, January 1958 and January 1959, and in all instances chorusing first occurred during the first two weeks of January. Chorusing has only been observed at two sites, Station 1 and at Station 8. Mating and egg-laying have only been observed at Station 1 at salinities ranging from 2.0 0/00 to 2.75 0/00. However, it is very probable that egg-laying also occurs at Station 2 and at Station 8 since frogs were congregated at these stations during early January but adequate field work was not done to check this possibility.

Through the two years Stations 1 and 2 in Harper's Well Wash proved to have the most persistent and largest population of frogs. It

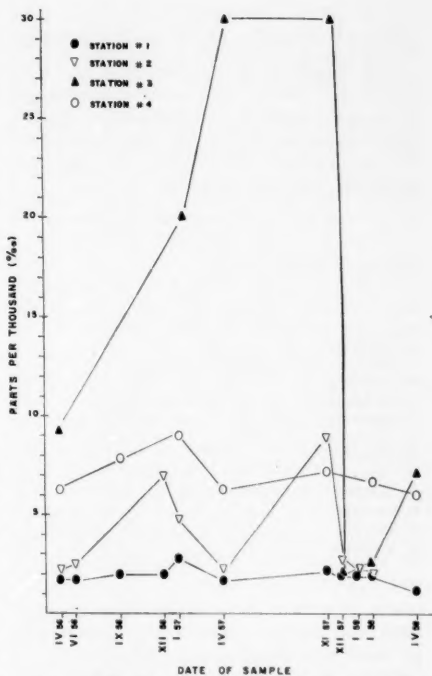


Fig. 2.—Fluctuation in the salinity of four of the stations in San Felipe Creek. Station 1 is a small flowing seepage, Station 2 is a flowing pool, Station 3 is an isolated pool, and Station 4 is the main channel of San Felipe Creek. See Figure 1.

was always possible to locate specimens of *Rana pipiens* at Harper's Well Wash, while it was often impossible to observe frogs at any other station.

Determination of salinity tolerance.—The data in Table 1 is the result of exposing San Felipe Creek eggs as well as Vermont and "Wisconsin" eggs to various concentrations. The data clearly indicate that salinities above 5 0/00 are lethal to the developing eggs. At these concentrations all the eggs form exogastrulas. If the embryo survives past this abnormal gastrulation (it usually does in concentration below 6 0/00) the anterior neural groove usually fails to close and the embryo will then die, usually sometime after the controls have reached stage 20 (gill circulation) of Shumway (1940). These embryos are characterized by other morphological abnormalities such as extremely short body, malformed gills, and short recurved tails. Salinities be-

TABLE 1

SALINITY TOLERANCE OF THE EGGS OF *Rana pipiens*

Eggs introduced into the solution at stage 2 or stage 3. A + sign indicates successful development of the eggs to stage 23. A - sign indicates that the concentration was lethal to the eggs during or before stage 23. Each cross consists of the eggs from a different female and male frog.

Cross (locality of parents)	Concentrations in Parts per Thousand (0/00)							
	Less than 1	1.2-1.4	2.0-2.5	3.0-3.4	3.8-4.2	4.5-4.6	5.0-5.1	5.5-6.2
1. California	+	+		+				-
2. California	+	+		+				-
3. California	+	+		+				-
4. California	+		+	+	+			-
5. California	+			+	+			-
6. California	+			+	+	+	-	-
7. California	+			+	+	+	-	-
8. Vermont	+	+	+	+	+			-
9. Vermont	+	+	+	+	-			-
10. Vermont	+	+	+	+			-	-
11. Wisconsin	+		+	+	+	+	-	-
12. Wisconsin	+			+	+	+	-	-

tween 3.8 0/00 and 4.6 0/00 have a variable effect and may be considered as semi-lethal. In most cases development was successful at salinities between 3.8 and 4.6 0/00, even though abnormalities in the form of enlarged yolk-plugs during late gastrula and short bodies during tail-bud stage were observable. In eggs from two other crosses the concentrations proved lethal in the same manner that concentrations above 5 0/00 caused death. Below 3.8 0/00 development was always successful. However, it should be emphasized that some form of developmental defect or abnormality was observable in any batch of eggs at a concentration of 2.5 0/00 or higher. The clearest morphological effect of these salinities was the size of the yolk-plug at the end of gastrulation. The higher the concentration, the larger the size of the yolk-plug. Actually the eggs could always be arranged in a graded series from lower to higher concentration merely by comparing the yolk-plug size in the different bowls.

The data demonstrate that there is no difference in tolerance between the San Felipe eggs and the Vermont and "Wisconsin" eggs.

Little work was done to determine the tolerance of adults. In the laboratory San Felipe and "Wisconsin" frogs were maintained successfully for three months in pens containing water having a concentration of 6.0 0/00. It was also determined that both San Felipe and

"Wisconsin" frogs are rapidly killed (3 hours) by a concentration of 13 0/00.

DISCUSSION

The major portion of San Felipe Creek is characterized by concentrations lethal to the eggs of *Rana pipiens*. A concentration of 5 0/00 is lethal to the eggs; however, the range of concentrations from 3.8 0/00 to 4.5 0/00 is semi-lethal since the eggs from some of the crosses were killed by these concentrations (see Table 1). The abundance of frogs at Harper's Well Wash may consequently be a direct result of a high survival of offspring due to the extremely low and uniform salinities of this locality. This is the only station (Station 1) that was repeatedly tested and that always yielded concentration values below 3 0/00. The main channel of San Felipe Creek is certainly closed to successful breeding since the concentrations of the samples obtained have always been above the lethal minimum. Chorusing of frogs was observed at Station 8 in Carrizo Creek where the salinity values ranged from 4.25 0/00 to 5.50 0/00. These concentrations are at the lethal minimum and consequently it is presumed that eggs laid at this site would die. All these data indicate that the population of *Rana pipiens* in San Felipe Creek successfully inhabits this marginal habitat without any pronounced resistance to the high concentrations of the stream. The data comparing the tolerance of San Felipe eggs to that of Vermont and "Wisconsin," indicate that the tolerance of the San Felipe population is no greater than that of the other populations of *R. pipiens*. The success of the species in this site can only be attributed to the fact that small portions of the habitat (Harper's Well Wash and possibly other localities such as Station 10, which has a concentration of 2.25 0/00), have a concentration low enough to permit successful reproductions.

The lethal minimum salt concentration for adult specimens of *Rana pipiens* lies between 6 0/00 and 13 0/00. The experiments of Brunacci (1914a) with *Rana esculenta* demonstrated that this species could tolerate concentrations up to 10 0/00. Adult specimens of *R. pipiens* have been collected in San Felipe Creek at concentrations as high as 9 0/00. Assuming that *Rana pipiens* has a limit near 10 0/00 would imply that most of the San Felipe Creek habitat is readily available to the adult frogs.

A question that remains to be answered in this study is: How long has *R. pipiens* in-

habited
larly in
ermos
southw
in the
possibi
San Fe
San Fe
and ab
the Sal
from a
fields o
water
can Ca
River
known
includ
does o
Yuma.
outnum
frog. I
system
catesbe
Creek.

The
Creek,
drying
LeCon
Sea) t
well-m
ent lev
Lake I
(1858)
habite
pearan
All of
San Fe
the an
not ha
Conte
Harpe
tion of
dicat
abund
the C
Blake
in the
the sa
scribe
Lak
forme
fish f
Hubb
the C
bilty
taine
River
are de

habited this site? This question is particularly important since this locality is the westernmost extension of this species in the southwestern United States (it is not found in the mountains west of the desert) and the possibility exists that it may have entered San Felipe Creek through the agency of man. San Felipe Creek empties into the Salton Sea, and about 200 yards before the stream enters the Salton Sea, it receives intermittent water from a drainage canal that drains irrigated fields to the east and south. The irrigation water for these fields is from the All-American Canal originating in the lower Colorado River near Yuma, Arizona. *Rana pipiens* is known to be native to the Colorado River, including the lower Colorado, and *R. pipiens* does occur in the irrigation canals near Yuma. However, it is relatively rare and far outnumbered by *Rana catesbeiana*, the bullfrog. It is interesting that, if the irrigation system does offer a route of migration, *R. catesbeiana* has failed to invade San Felipe Creek.

The age of San Felipe Creek, Carrizo Creek, and Harper's Well Wash dates to the drying up of the ancient freshwater Lake LeConte (also called Lake Cahuilla or Blake Sea) that filled the Salton Sink and left a well-marked shore line high above the present level of the Salton Sea. The drying up of Lake LeConte is relatively recent since Blake (1858) claims that the Indians that then inhabited the area described the slow disappearance of a lake in the time of their fathers. All of the surface water of the present day San Felipe Creek emerges below the level of the ancient shoreline and consequently could not have existed during the time of Lake LeConte. Indian artifacts are abundant near Harper's Well Wash, as well as near the junction of Carrizo and San Felipe Creek, and indicate that the Indians made use of the water abundant here but rare through the rest of the Colorado Desert. LeConte (1855) and Blake (*op. cit.*) both visited San Felipe Creek in the 19th Century and describe it in much the same words that would be used to describe it at present.

Lake LeConte appears to have been formed primarily by the Colorado River. The fish fauna of Lake LeConte, according to Hubbs and Miller (1948), was derived from the Colorado River. Consequently the possibility exists that the ancient lake also contained *R. pipiens* derived from the Colorado River, and that the present San Felipe frogs are descendants of this original population.

This would help explain the absence of *R. catesbeiana* from San Felipe Creek since this species was unknown in the Colorado River until introduced by man sometime during this century.

Review of literature.—Few determinations of the salinity tolerance of amphibian eggs have been made. Holtfreter (1943) using *R. pipiens* eggs and Ringer's solution noted the early death of eggs at a concentration of 6.8 0/00. He also observed abnormal development with the loss of mesectoderm at a concentration of 5 0/00. Holtfreter does not mention how long he observed the embryos in 5 0/00, but from the results that I have obtained the loss of mesectoderm accompanies the failure of the neural groove to close over and usually occurs at lethal concentrations. The only other detailed test of egg tolerances is that of Ely (1944) using *Bufo marinus* eggs and dilutions of sea water. Ely observed the successful development of embryos at a concentration as high as 5.4 0/00 (15% sea water). This indicates that *B. marinus* shows a higher tolerance than *R. pipiens* where the maximum concentration tolerated is less than 5 0/00.

The most complete study on the tolerance of adult amphibians to salt concentrations is that of Brunacci (1914a). Using *Rana esculenta* and Ringer's solution Brunacci placed groups of adult frogs in various concentrations of Ringer's (concentrations ranged from 9 0/00 to 15 0/00) and observed for a period of up to five days. The frogs and solution were kept at a constant temperature (12°C). The highest concentration at which no deaths occurred was 10.5 0/00. Brunacci in a series of other papers (1914b, 1915a, 1915b) also studies the freezing point depression of various body fluids and the function of the lymphatic sacs as related to the various concentrations to which he exposed the frogs. Duval (1928) using *Rana temporaria* and concentrations of sea water found that the maximum concentration that the adults could survive for a few days was between 8.5 0/00 and 9.7 0/00.

Bertin (1920) describes a population of *R. temporaria* inhabiting a brackish coastal marsh in Brittany and claimed that concentrations above 7 0/00 killed the adult frogs. Rose (1926) using a single half-grown specimen of *Xenopus laevis* determined that it could tolerate concentration as high as 11 0/00.

Pearse (1911) describes the occurrence of frog tadpoles and adults in a tidal stream in

TABLE 2
LIST OF AMPHIBIANS FOUND ASSOCIATED IN NATURE
WITH BRACKISH OR MARINE WATER

Species	Author
<i>Bufo bufo</i>	Hardy, 1943
<i>Bufo boreas</i>	Stebbins, 1951; Storer, 1925; Brues, 1932
<i>Bufo calamita</i>	Hardy, <i>op. cit.</i> ; Mertens, 1926; Boulenger, 1897
<i>Bufo marinus</i>	La Rivers, 1948
<i>Bufo melanostictus</i>	Annandale, 1907
<i>Bufo raddei</i>	Shaw, 1934
<i>Bufo viridis</i>	Mertens <i>op. cit.</i> ; Werner 1909; Boulenger, <i>op. cit.</i>
<i>Hyla cinerea</i>	Peterson, <i>et al.</i> , 1952
<i>Hyla septentrionalis</i>	Peterson, <i>et al.</i> , <i>op. cit.</i>
<i>Hyla regilla</i>	Brues, <i>op. cit.</i>
<i>Microhyla carolinensis</i>	Peterson, <i>et al.</i> , <i>op. cit.</i>
<i>Rana arvalis</i>	Mertens, <i>op. cit.</i>
<i>Rana cancrivora</i>	Pearse, 1911; Inger, 1954; Boulenger, 1920
<i>Rana catesbeiana</i>	La Rivers, <i>op. cit.</i>
<i>Rana cyanophlyctis</i>	Annandale, <i>op. cit.</i>
<i>Rana esculenta</i>	Mertens, <i>op. cit.</i>
<i>Rana pipiens</i>	Pearse, 1936
<i>Rana pretiosa</i>	Brues, <i>op. cit.</i>
<i>Rana ribibunda</i>	Mertens, <i>op. cit.</i> ; Werner, <i>op. cit.</i>
<i>Rana temporaria</i>	Bertin, 1920; Hardy, <i>op. cit.</i> ; Mertens, <i>op. cit.</i>
<i>Rana tigrina</i>	Annandale, <i>op. cit.</i>
<i>Scaphiopus</i> sp.	Brues, <i>op. cit.</i>
<i>Ambystoma subsalsum</i>	Taylor, 1943
<i>Triturus helveticus</i>	Spurway, 1943
<i>Triturus vulgaris</i>	Hardy, <i>op. cit.</i>

the Philippines. The adult frogs, *Rana cancrivora* (see Inger, 1954), and the tadpoles were in water that had concentrations as high as 21 0/00. Pearse (1936) also recorded adult *R. pipiens* in coastal North Carolina in brackish waters ranging from 3.5 0/00 to 21 0/00. These high concentrations are surprising considering the fact that all the experimental data of Duval, Brunacci and Bertin indicate that frogs die when exposed to concentrations approximating 10 0/00. Concentrations of 21 0/00 as reported by Pearse could conceivably only be tolerated for short periods of time by the adult frogs. It is of course possible that *R. cancrivora* on further investigation may prove to be markedly more tolerant than other species of anurans. The tadpoles found in the tidal stream at such high concentrations probably developed from eggs laid upstream in fresh water and then carried down to the tidal area. The resistance of the embryos varies depending on the stage of development that is tested, but it is nevertheless surprising that Pearse should find metamorphosing tadpoles in a concentration of 21 0/00.

Brues (1932) cites a number of species (see Table 2) of western North American anurans that he found in warm brackish springs. Tadpoles as well as adults were found in concentrations ranging from 3 0/00 to 7.4 0/00.*

Little data are available regarding the concentration tolerance of urodeles. Spurway (1943) found larvae of *Triturus helveticus* in coastal brackish pools in Scotland. The salinity of the pools varied from less than 1 0/00 to 24 0/00. Spurway found that the larvae died in concentrations of 24 0/00 but survived concentrations of 2 0/00. Taylor (1943) described a new species of salamander, *Ambystoma subsalsum*, from a brackish water lake in Mexico. The water of the lake had a concentration of 8.3 0/00. Young as well as adult specimens were secured from the lake and thus indicated that breeding may occur in the lake.

Schmidt (1957) provided an incomplete bibliography of references to the brackish water association of amphibians. In Table 2 a list of the species of amphibians that have been found in nature associated with brackish water is provided together with the author of the reference. This list is also probably incomplete. The majority of the articles in this list (with the exception of those also cited in the text) are merely descriptive and presume the brackish nature of the water without any determination of the actual concentration of the water or tolerance of the organism. Regardless of this failing the list indicates that the existence of amphibians in a brackish medium is by no means rare. The anurans by far outnumber the urodeles on the list, but this is not unexpected considering the greater abundance of anurans.

From the fragmentary information gained in the literature it appears that there are few, if any, cases of amphibians adapted to high salinities. That is to say amphibians in which the eggs as well as the adults have a tolerance to high concentrations. Nevertheless it is also evident that adult amphibians are capable of tolerating moderate concentrations and that the upper limit is near 10 0/00. Certainly the number of species listed in Table 2 indicates that this tolerance may be a general characteristic of all amphibians. The eggs have a much lower limit ranging from about 4.5 0/00 for *Rana pipiens* to about 5.4 0/00 for *Bufo marinus*. It is possible that *Rana can-*

* Brues measure of the concentrations was by determining the specific gravity of the water at 15°C. I have converted his specific gravity determinations to parts per thousand by use of the "Hydrographical Tables" (Knudsen, 1901). This introduces a certain error since the tables are based on sea water at 17.5°C.

crivora, on further study, may prove to have a higher tolerance than other species of amphibians. It is similarly unknown whether the European *Bufo calamita* has a higher tolerance than other anurans. Thus as Smith (1954) has remarked, the often mentioned brackish water tolerance of *B. calamita* has yet to be experimentally demonstrated. Similarly the interesting association of *Bufo boreas* with the saline waters of Pyramid Lake, in Nevada (Stebbins, 1951) has never been studied.

SUMMARY AND CONCLUSIONS

1. A population of frogs of the species *Rana pipiens* is described which inhabits San Felipe Creek, a saline desert stream. The salt concentration of the stream varies at different stations along the stream and any given station was found to show considerable fluctuation in salinity over a two-year period. The various concentrations obtained ranged between 1.75 0/00 and 34 0/00.

2. The tolerance of the eggs of *R. pipiens* to various concentrations was determined for San Felipe frogs as well as for frogs from non-brackish habitats (i.e., Vermont and "Wisconsin"). The minimum lethal concentration was 5 0/00 while concentrations ranging from 3.8 0/00 to 4.5 0/00 were semi-lethal. No difference was detected in the tolerance of eggs from non-brackish habitats as compared to San Felipe eggs.

3. Adult frogs from San Felipe and "Wisconsin" were found to successfully tolerate a concentration of 6 0/00 for three months. A concentration of 13 0/00 rapidly killed the frogs.

4. The tolerance limits of the eggs of San Felipe frogs indicate that these eggs are not adapted to tolerate higher concentrations than the eggs of populations from non-brackish areas. The major portion of San Felipe Creek has a concentration lethal to the eggs. Consequently the successful habitation of San Felipe Creek by *R. pipiens* is due to the existence of a few seepages along the stream that have concentrations below 3 0/00.

5. It has yet to be determined whether the frogs in the San Felipe area are native or the result of introduction through the agency of man.

6. The literature on the salinity tolerance of amphibians is reviewed and a list of the species reportedly occurring in brackish or marine water is provided.

ACKNOWLEDGMENTS

Financial assistance for this project was provided by an intramural research grant of the University of California. I also wish to take this opportunity to thank my numerous colleagues and students who assisted me in the field. I am particularly grateful to Dr. Wilbur Mayhew and Mr. Steven Anderson for their assistance and pleasant company.

LITERATURE CITED

- ANNANDALE, N. 1907. The fauna of brackish ponds at Port Canning, Lower Bengal. Part I. Introduction and preliminary account of the fauna. *Rec. Ind. Mus.* 1:35-43.
- BERTIN, L. 1920. Les grenouilles peuvent-elles s'adapter à l'eau saumâtre? *Compt. Rendus Soc. Biol.* 83:1308.
- BLAKE, W. P. 1858. Report of a geological reconnaissance in California. *H. Bailliere, N. Y.* 370 pp.
- BOULENGER, G. A. 1897. The tailless batrachians of Europe. *Ray Soc., London.* iii + 210 pp.
- . 1920. A monograph of the South Asian, Papuan, Melanesian and Australian frogs of the genus *Rana*. *Rec. Ind. Mus.* 20:1-226.
- BRUES, C. T. 1932. Further studies on the fauna of North American hot springs. *Proc. Amer. Acad. Arts Sci.* 67:185-303.
- BRUNACCI, B. 1914a. Sull'adattamento degli anfibii all'ambiente liquido esterno mediante la regolazione della pressione osmotica dei loro liquidi interni. I. *Rend. Accad. Lincei* (5), 23:fasc. 1:512-518.
- . 1914b. [same title] II. *Rend. Accad. Lincei* (5), 23:fasc. 1:622-624.
- . 1915a. [same title] IV. *Rend. Accad. Lincei* (5), 24:fasc. 1:272-276.
- . 1915b. [same title] VI. *Rend. Accad. Lincei* (5), 24:fasc. 1:992-995.
- DUVAL, M. 1928. L'adaptation des grenouilles à l'eau saumâtre. *Ann. Physiol. Physiochem. Biol.* 4:181-189.
- ELY, C. A. 1944. Development of *Bufo marinus* larvae in dilute sea water. *Copeia* 1944 (4):256.
- HARDY, E. 1943. Newt larvae in brackish water. *Nature* 151:226.
- HOLTFRETER, J. 1943. Properties and functions of the surface coat in amphibian embryos. *Jour. Exp. Zool.* 93:251-323.
- HUBBS, C. L., AND R. R. MILLER. 1948. The Great Basin. II. The zoological evidence. *Bull. Univ. Utah* 38: (Biol. Ser. 10:7):18-166.
- INGER, R. F. 1954. Systematics and zoogeography of Philippine amphibia. *Fieldiana: Zool.* 33:183-531.
- KNUDSEN, M. 1901. Hydrographical tables. *Copenhagen.*
- LARIVERS, I. 1948. Some Hawaiian ecological notes. *Wasman Collector* 7:85-110.
- LECONTE, J. 1855. An account of some volcanic springs in the desert of the Colorado in southern California. *Amer. Jour. Sci. Arts* 19:1-6.
- MERTENS, R. 1926. Amphibia, reptilia. Die Tierwelt der Nord- und Ostsee, Part XII, Lfg. i:1-20.
- PEARSE, A. S. 1911. Concerning the development of frog tadpoles in sea water. *Philippine Jour. Sci.* 6:219-20.

- . 1936. Estuarine animals at Beaufort, North Carolina. *Jour. Elisha Mitchell Sci. Soc.* 52:174-222.
- PETERSON, H. W., R. GARRETT, AND J. P. LANTZ. 1952. The mating period of the giant tree frog *Hyla dominicensis*. *Herpetologica* 8:63.
- ROSE, W. 1926. Some field notes on the Batrachia of the Cape Peninsula. *Ann. S. African Mus.* 20:433-450.
- SCHMIDT, K. P. 1957. Amphibians (annotated bibliography). *Geol. Soc. Amer. Mem.* 67:1211-1212.
- SHAW, TSEN-HWANG. 1934. Notes on specimens of Radde's toad from Chefoo. *China Jour.* 20:197-199.
- SHUMWAY, W. 1940. Stages in the normal development of *Rana pipiens*. I. External form. *Anat. Rec.* 78:139-147.
- SMITH, M. 1927. Contributions to the herpetology of the Indio-Australian region. *Proc. Zool. Soc. London* 199-225.
- . 1954. The British amphibians and reptiles. *Collins, London.* xiv + 322 pp.
- SPURWAY, H. 1943. Newt larvae in brackish water. *Nature* 151:109-110.
- STEBBINS, R. C. 1951. Amphibians of western North American. *Univ. Calif. Press, Berkeley.* ix + 539 pp.
- STORER, T. L. 1925. A synopsis of the amphibia of California. *Univ. Calif. Publ. Zool.* 27:1-342.
- TAYLOR, E. H. 1943. A new ambystomid salamander adapted to brackish water. *Copeia* 1943 (3):151-156.
- WERNER, F. 1909. Reptilien, Batrachien und Fische von Tripolis und Barka. *Zool. Jahrb. Syst.* 27:595-646.

DIVISION OF LIFE SCIENCES, UNIVERSITY OF CALIFORNIA, RIVERSIDE, CALIFORNIA.

Effect of Temperature on Call of the Frog, *Bombina variegata*

RICHARD G. ZWEIFEL

THERE have been several investigations of the relationship of temperature to variation in the mating calls of anurans. The variables most often noted in mating calls are pitch, duration, and the rate of repetition. In general, pitch and rate of repetition show a positive correlation with temperature, whereas there is a negative correlation of temperature and the duration of call. Most of the information that deals with correlations of variations with temperature is based on data gathered in the field. As a rule, the sizes or the precise temperatures of the individual frogs comprising the samples could not be obtained. Hence, investigators usually have been uncertain whether the variations result from individual differences, temperature differences, or other variables. In this study, the data recorded for the mating call of a single frog at various temperature levels are analyzed. The information thus obtained demonstrates the amount of variation encountered under relatively well-controlled conditions, and provides a basis for evaluating data gathered in the field.

MATERIALS AND METHODS

The male frog used in these experiments, *Bombina variegata variegata* (Linné), 45 mm. in snout-vent length, was captured near St. Gallen, Switzerland, in May, 1957 by Mr. Myles Walsh, III, and received at the Ameri-

can Museum of Natural History a few days after capture. Along with several females of the same species collected at the same time, it is still alive at this writing in the small aquarium where it has been kept. The frogs are well-adapted to the conditions of captivity as attested by their successful breeding activity almost a year after capture. Throughout much of the year, but especially in the spring, the male frog called at night and at times during the day. As the frog calls from the water with only part of the head protruding, its body temperature presumably closely approximates the temperature of the water. Temperatures recorded in this paper are water temperatures taken within an inch or so of the frog while it was calling. Tape recordings of the call were made at various temperatures with a Magnemite, Model 610SD, operating at a tape speed of 7.5 inches per second and an Electrovoice, Model 647, dynamic microphone. Sonagrams and sections made from these recordings with a commercial sound spectrograph known as the Sonagraph provide the basis for objective analysis of duration and pitch of call. Briefly, the Sonagraph produces a graphic record (or "Sonagram") of the duration (horizontal axis) and frequency up to 8000 cycles per second (vertical axis) of a sample of sound 2.4 seconds in length by tracings on sensitized paper. The third dimension of relative intensity of

KILOCYCLES PER SECOND

Fig. a seq

sound of the Sonagram of an section quence gram frequ accurate gram. were c to an rate o the re from the fr

The 157) a It com peate This from pressi seen little durat sac (H obser indic air fr the l norm accom woul is pr bomb

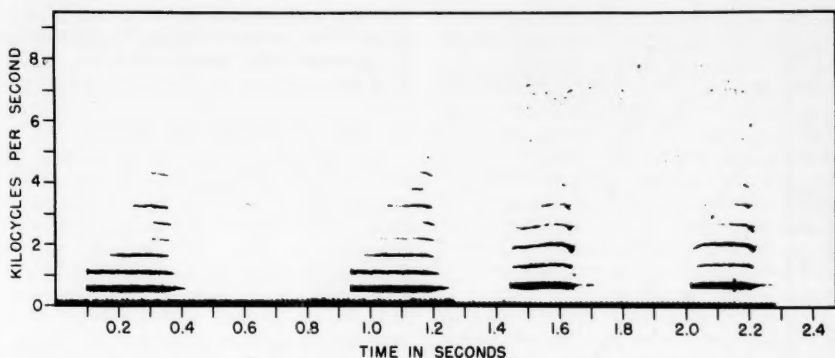


Fig. 1.—Sonogram of the mating call of *Bombina variegata*. The two calls to the left are from a sequence recorded at 16.8°C.; the two to the right were given by the same frog at 24.4°C.

sound is read in the darkness of various parts of the tracing. An example of the resultant Sonogram is seen in figure 1. A second form of analysis is the section (not illustrated). A section is a display of amplitude against frequency for a single selected point of a Sonogram tracing, and is useful in determining frequency and relative intensity with more accuracy than they can be read from a Sonogram. Frequencies mentioned in this study were determined from sections, and were read to an accuracy of plus or minus 25 cycles. The rate of call was measured by direct count from the recordings while being played back and from the actual call as it was being uttered by the frog.

THE CALL OF *Bombina variegata*

The call is described by Boulenger (1897: 157) as a "low and mournful note, hoo, hoo." It consists of a series of monotonously repeated short, low-pitched, soft untrilled notes. This is a rather weak call, which when heard from only a few feet away may give the impression of coming from a great distance. As seen in a Sonogram (Fig. 1), the call shows little or no change of pitch during its short duration. *Bombina variegata* has no vocal sac (Boulenger, 1897:155; Liu, 1935:29), and observations made on the captive individual indicate that the call is produced by forcing air from the inflated buccal cavity back into the lungs, essentially an exaggeration of normal inspiration. Deflation of the throat is accompanied by production of sound. It would be of interest to know whether the call is produced in similar way in *Bombina bombina*, a closely related species that pos-

sesses primitive internal vocal sacs (Liu, 1935:22).

RATE OF CALL

The rate of call is expressed as calls per minute. Twenty-two determinations were made through a temperature range from 16.8° to 25.6°C. The minimum length of time for any one determination was 15 seconds, though many of the records represent counts taken over a longer period of time. As the illustration (Fig. 2) makes plain, there is a strong positive correlation of calling rate with temperature. The individual points are

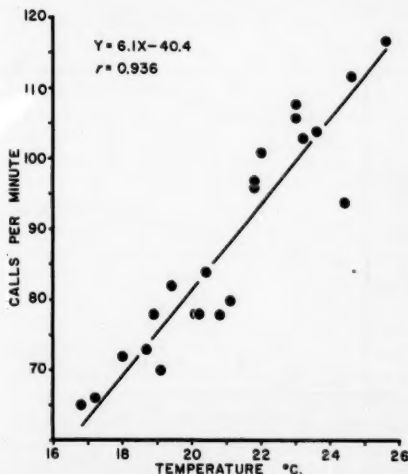


Fig. 2.—Relationship of rate of call to temperature of an individual of *Bombina variegata*.

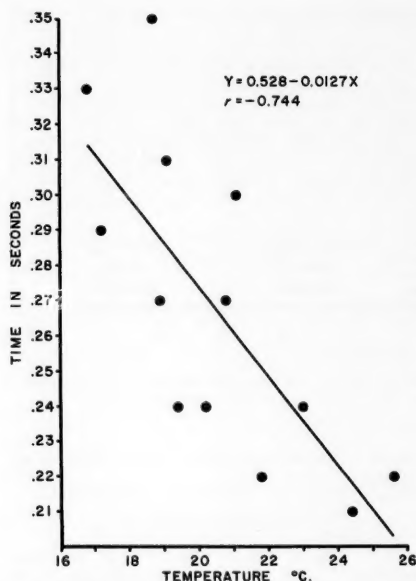


Fig. 3.—Relationship of call length to temperature of an individual of *Bombina variegata*.

closely grouped about the regression line, with a resultant very high coefficient of correlation ($r = 0.936$). Within the temperature range 16.8° – 25.6°C ., the observed range of variation is 65–117 calls per minute. By extrapolation, a rate of 123 calls per minute at 26.8°C . may be estimated. Thus for a ten

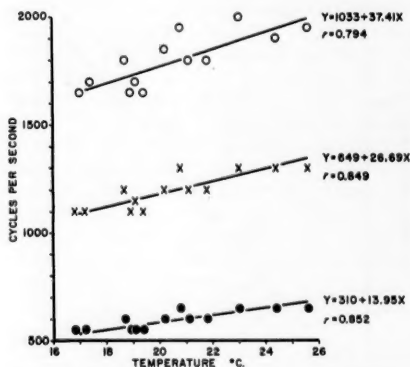


Fig. 4.—Relationship of pitch to temperature in the call of an individual of *Bombina variegata*. The lower plots (●) represent the fundamental tone; the middle (×) and upper (○) plots, respectively, represent the first and second harmonics.

degree rise in temperature, the average rate of call (that measured by the regression line) is approximately doubled—from 62 to 123 calls per minute.

DURATION OF CALL

The duration of call was determined by measurement of Sonagram tracings. Data from 13 tape recordings made at temperatures ranging from 16.8° to 25.6°C . are plotted in figure 3. Each point represents the average duration of three or four individual calls given at the temperature indicated. The calls of any given sequence seldom differed from one another by more than 0.01 or 0.02 seconds, though in one instance the difference amounted to 0.04 seconds. There is clearly a tendency for the length of each individual call to be shorter at higher temperatures, but the length of the call is variable, as is indicated by the relatively low (but significant) coefficient of correlation ($r = 0.744$). The low value of r would also result if the relationship of call length to temperature were not rectilinear. On the scatter diagram the points do, in fact, appear to trace a slight curve. However, much of this apparent curvature is due to a single point that lies at 18.7°C . and 0.35 seconds. Elimination of this point gives (as the reader may verify empirically) a decidedly less curved aspect to the pattern. The suggestion that this record represents an abnormal call is reinforced by other considerations: the length of individual calls in this sequence varies over a duration of 0.04 seconds, rather than 0.01 or 0.02 seconds as is seen in other records, and the first harmonic rather than the fundamental is emphasized. However, in such a small sample the significance of this apparently but not certainly unusual call cannot be determined.

PITCH

The call is simple harmonically, consisting of a fundamental at 550–650 cycles per second at the temperatures at which calls were studied, and a series of up to nine harmonics reaching to about 5500 cycles per second. As a rule, the fundamental is by far the strongest, with the second harmonic slightly emphasized. In two of the 13 calls analyzed the first harmonic rather than the fundamental is dominant. The amount of energy in levels above the second harmonic falls off rapidly, and these higher levels probably contribute little to the character of the sound. Data relating to temperature and frequency are presented graphically (Fig. 4) for the funda-

mental, first and second harmonics. There is a significant positive correlation between pitch and temperature. The fundamental rises from about 550 c.p.s. to about 650 c.p.s. For the benefit of those who may wish to consider this in musical terms, the difference is approximately the interval of a minor third, C \sharp^1 (554 c.p.s.) to E \sharp^1 (659 c.p.s.). The harmonics rise in predictable fashion: the first from 1100 to 1300 c.p.s.; the second from 1650 to 1950 c.p.s.

The dominant frequency in *Bombina* is much lower than is usual in small frogs, a situation probably due to the absence of a vocal sac than might tend to emphasize a higher harmonic.

DISCUSSION

The only data available that are closely comparable to those presented here for *Bombina* are given by Blair (1958:30), who recorded the call of a single individual of *Hyla versicolor* nine times at air temperatures ranging from 18° to 27°C. The variables measured are dominant frequency in cycles per second, duration of call, and pulses per second (the call of *H. versicolor* is a trill). The repetition rate of the call is not given, but the number of pulses per second is a similar phenomenon. In view of the relative paucity of records and the possibility of difference between air temperature and the body temperature of the frog, it is difficult to assess the significance of the observed variation, but the average effect of temperature on the variables is easily seen. Trill rate and dominant frequency are correlated positively with temperature, and length of call shows a negative correlation. Blair gives eight records ranging from 22°–27°C. and a single lower temperature record at 18°C. The lower record is anomalous in that the trill rate seems too high, with length of call too short by comparison with the trend evident in the other records; however, the pitch is more in line. It is possible that variation such as is seen here at 18°, as well as other deviations from rectilinearity noted below, may be caused by compensation for temperature (reviewed by Bullock, 1955). Acclimation to temperature in anuran calls appears to offer an untouched field for study. However, if the record at 18°C. may be ignored as possibly abnormal, the scatter of the data appears to be similar to that seen in *Bombina*, with duration of call somewhat more variable than trill (repetition) rate. For reasons that will be made evident subsequently, comparison of relative effect on dominant frequency is not practical.

The relationship of temperature to rate of call has been investigated in several species in addition to *Hyla versicolor*. Jackson (1952) presents data on the variation of call rate of the cricket frog, *Acris crepitans*, as effected by temperature. His data show considerable scatter. From the raw data given by him, the correlation coefficient $r = 0.71$ may be calculated. This relatively low (though significant) correlation probably, as Jackson realizes, is related to the fact that the air temperatures recorded did not correspond in many cases to the actual body temperatures of the frogs. In *Pseudacris streckeri*, a species that calls on land at the margins of pools, Bellis (1957) finds no correlation between air temperature and call rate. Two related species that call from a partly submerged position, *P. triseriata* and *P. clarki*, each show a strong positive correlation with water temperature. To judge from Bellis' scatter diagrams, the variation in these two species is somewhat greater than reported here for *Bombina*. This is to be expected, because of individual variation among the many frogs involved, and the differences between the water temperature and that of the frogs. As an example of individual variation in the calls of anurans in a single breeding population, Blair (1958:30) presents data on calls of 17 *Pseudacris streckeri* recorded at the same time and place. In view of the complete lack of correlation of air temperature and call rate in this species observed by Bellis, it seems possible that the individual variation reported by Blair is in part at least due to different temperatures of individual frogs. With only one record at each of four temperatures, Harper (1937:265–6) finds a virtually straight-line relationship between call rate of *Pseudacris ornata* and air temperature. Presumably a larger sample would reveal a picture of variation similar to that in other *Pseudacris*.

The most complete information in the literature with respect to the effect of temperature on duration of call is that of Bellis (1957:86) for *Pseudacris triseriata*. As in *Hyla versicolor* and *Bombina variegata*, the length of the call is markedly reduced at higher temperatures. As in *Bombina*, there is here too a suggestion that the relationship may not be strictly rectilinear. As seen in his scatter diagram (Fig. 2), the majority of records at higher temperatures fall above the regression line, the slope of which is largely determined by the mass of records at lower temperatures.

The only extensive analysis of correlated variation in temperature and dominant frequency is that of Blair (1955b) for two closely related species of frogs, *Microhyla olivacea* and *M. carolinensis*. In Blair's data for *M. olivacea* the frequency shows a much closer correlation with temperature than is apparent in *M. carolinensis*: the correlation coefficients given by Blair are, respectively, 0.883 and 0.273. The first corresponds to a probability of much less than 0.01, but that for *carolinensis* is at a level that verges upon non-significance—0.02. I doubt that there is actually a significant difference in the correlation with temperature in the two species. Perhaps some factor such as a slight difference in the calling habits of the two species makes water temperature a more meaningful measure in *olivacea* than in *carolinensis*.

The two species of *Microhyla* differ not only in dominant frequency, but in the relative magnitude of the effect of temperature on frequency. The regression line for *olivacea* rises about 950 c.p.s. for a ten degree rise in temperature, whereas the increase in dominant frequency over the same interval in *carolinensis* is only about 275 c.p.s. (Blair, 1955b, Fig. 3). This difference between the species is to be explained, at least in part, by the different positions of the emphasized frequencies in the spectrum of harmonics. The calls of the two species are similar in that each consists of a low-pitched fundamental and a series of closely spaced harmonics. In the Sonagram of *carolinensis* published by Blair (Fig. 2), the 14th through 17th harmonics are most heavily accented, whereas in the Sonagram of *olivacea* the 17th through 22nd are emphasized. The relative increase of frequency with temperature depends upon the position of the harmonic measured in the harmonic series. If the emphasized band is close to the fundamental, the increase in frequency with temperature is less than if a higher harmonic is emphasized. This may be seen in figure 4, where the first harmonic in the call of *Bombina* rises 200 c.p.s., whereas the second harmonic rises 300 c.p.s., and the fundamental rises only 100. The musical interval, of course, does not change; that is, the difference between fundamental and first harmonic is an octave at any temperature. It is evident that comparison of relative effect of temperature on pitch in different species must take into consideration the simple physical effect of difference between fundamental and emphasized harmonic.

Blair (1955b:470) remarks that "The relative expression of the various harmonics and bands of harmonics is presumably a function of the vocal pouch." That smaller species and smaller individuals of a species tend to have higher-pitched calls is well known. The difference in pitch between *Microhyla olivacea* and *M. carolinensis* may be directly related to the difference between the animals in body size (Blair, 1955a) and vocal pouch size, and may be a result of selection for body size rather than selection for difference in pitch. The two species also differ in duration of call, which Blair does not analyze as a function of temperature.

In two of the 13 recordings of *Bombina*, the first harmonic rather than the fundamental is the stronger element. The cause of this was not determined. If similar sporadic variation occurs in other frogs, as it very likely does, the importance to the frogs of slight differences in pitch may be questioned. In the case of the *Microhyla* studied by Blair, the variation observed is rather great. In *M. olivacea* the range of variation at a single water temperature is frequently as high as from 500 to 1000 c.p.s., which on the average is as much as would be expected from an increase in temperature of from 5° to 10°C. In *M. carolinensis* the situation appears more extreme: the variation here—from 400 to 600 c.p.s.—is equivalent to an average rise in temperature of from 15° to 22°C. Of course, the temperature data here could not be exact, and variation in body size among the many frogs probably accounts for much of the variation in pitch. In the populations studied by Blair, the importance of these variations is minimized by the more significant fact that at any given temperature there is no overlap in the ranges of variations for the two species.

Considering the three principal variables, that of repetition rate appears to show the highest correlation with temperature. This is clearly true for *Bombina*, and is indicated for *Hyla versicolor* and *Pseudacris nigrita* as well. Both duration and pitch are more variable at a given temperature than is repetition rate, and the possibility exists that the relationship of duration of call to temperature may not be rectilinear. Other factors being equal, it may be that the low variation of repetition rate renders it in many cases the best character for comparing individuals and populations.

A subject that remains to be studied objectively is the influence of the calls of one

individuals
others
upon
vestiga
as pre
or bo
and w
when

1. T
of Bo
tempe
and th
tition
and co
2. R
cycles
ently
ture.
related
exists
3. I
able a
rate;
may b
tion r
many
comp
tion.
4. T
pitch
differ
harmo
indivi
phasia

I ac
Charl

T H
p
Hyla
beari
resen

individual upon the calling behavior of others in an aggregation, and what effect upon rates might ensue. In any event, investigators should try to record temperatures as precisely as possible, stating whether air or body temperatures have been recorded, and whether the frog was in water or on land when calling.

SUMMARY

1. The mating call of a single individual of *Bombina variegata* was tape-recorded at temperatures ranging from 16.8° to 25.6°C., and the recordings analyzed for rate of repetition of the call, duration of individual calls, and component frequencies.

2. Repetition rate and pitch (frequency in cycles per second) show a positive and apparently rectilinear correlation with temperature. The duration of call is negatively correlated with temperature, and the possibility exists that the relationship is curvilinear.

3. Duration and frequency are more variable at a given temperature than repetition rate; data in the literature suggest that this may be true for other species as well. Repetition rate appears to be less variable and in many cases may be a better character for comparing populations than pitch or duration.

4. The relative effect of temperature on pitch (emphasized frequency) varies with the difference between the fundamental and the harmonic measured. Hence, in comparing individuals or populations, differences in emphasized harmonic level must be considered.

ACKNOWLEDGMENTS

I acknowledge with thanks the aid of Mr. Charles M. Bogert, who read and criticized

the manuscript, and Mrs. Frances W. Zweifel, who made several of the recordings of *Bombina* while tending to another nocturnally-calling member of the household. A special note of thanks is due Mr. Myles Walsh, III, who donated the *Bombina* and who, together with other members of his family, has collected numerous interesting and valuable exotic amphibians and reptiles for the American Museum of Natural History.

LITERATURE CITED

- BELLIS, EDWARD D. 1957. The effects of temperature on salientian breeding calls. *Copeia* 1957(2):85-89, 6 figs.
- BLAIR, W. FRANK. 1955a. Size difference as a possible isolation mechanism in *Microhyla*. *American Naturalist* 89:297-301, 2 tables, 2 figs.
- . 1955b. Mating call and stage of speciation in the *Microhyla olivacea*-*M. carolinensis* complex. *Evolution* 9:169-80, 1 table, 5 figs.
- . 1958. Mating call in the speciation of anuran amphibians. *American Naturalist* 92:27-31, 3 tables, 7 figs.
- BOULENGER, G. A. 1897. The tailless batrachians of Europe. Part I. London, The Ray Society: i-iii, 1-210, figs., pls., maps.
- BULLOCK, THEODORE H. 1955. Compensation for temperature in the metabolism and activity of poikilotherms. *Biol. Reviews* 30:311-42, 5 figs.
- HARPER, FRANCIS. 1937. A season with Holbrook's chorus frog (*Pseudacris ornata*). *Amer. Midl. Nat.* 18:260-72, 7 figs.
- JACKSON, ALBERT W. 1952. The effect of temperature, humidity, and barometric pressure on the rate of call in *Acris crepitans* Baird in Brazos County, Texas. *Herpetologica* 8:18-20, 1 table, 1 fig.
- LIU, CH'ENG CHAO. 1935. Types of vocal sac in the Salientia. *Proc. Boston Soc. Nat. Hist.* 31:19-40, 3 tables, 5 pls.

DEPARTMENT OF AMPHIBIANS AND REPTILES,
THE AMERICAN MUSEUM OF NATURAL HISTORY,
NEW YORK, NEW YORK.

Genetic Incompatibility in the Call Races of *Hyla versicolor* Le Conte in Texas

CLIFFORD JOHNSON

INTRODUCTION

THIS study was done to test genetic compatibility between two "call races" of *Hyla versicolor* and thus provide evidence bearing on the possibility that these may represent two discrete, although morphologically

little differentiated, species. The structure of the call for the two "call races" is shown in Figure 1.

Most of the literature concerning this species is represented by taxonomic treatments in the typological species concept. Recent

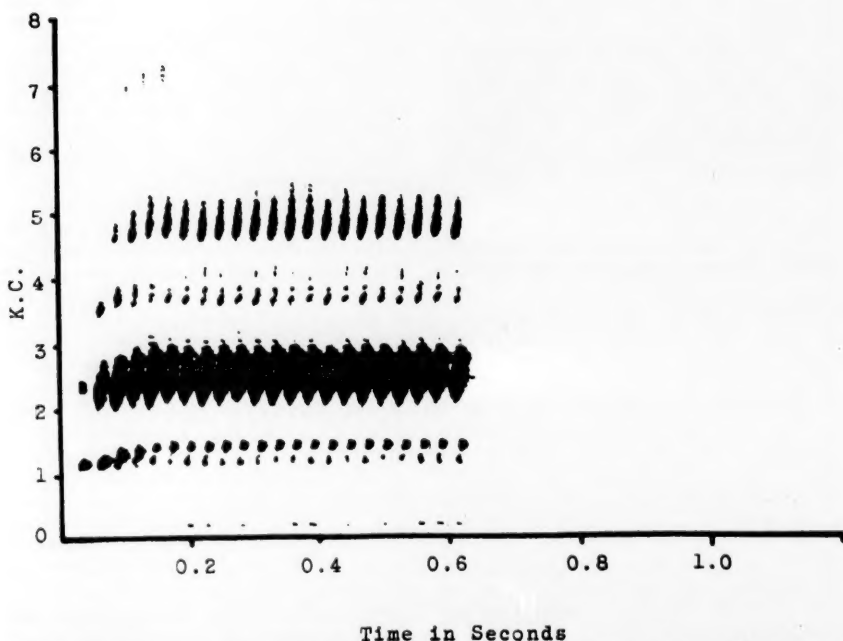
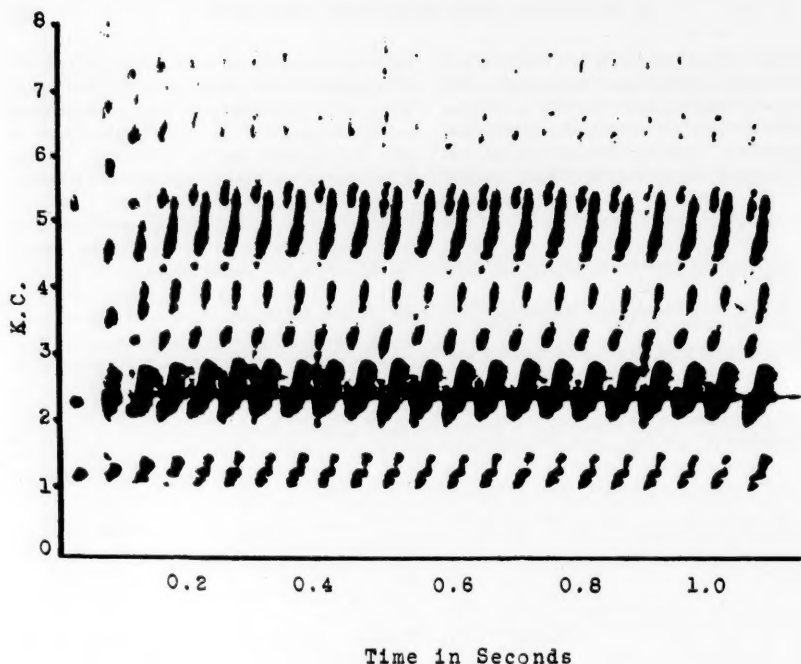


Fig. 1.—The upper sound spectrogram shows the typical call structure of the east Texas population and the lower is that of the central Texas population. The ordinate shows frequency, and the abscissa shows time. Darkness of marking shows intensity.

knowle
mits an
tionshi

Hyla
moder
eastern
portion
ern Fl
where
ently
morph
even l
tions.

The
origin
(1880)
and St
versico
H. v.
fused
(1928)
presen
synony
the no
versico
All of
tion o
skin.

The
has be
(1936)
and su
geogra
(1946)
differ
and I
scribed
has an
trogra
popul
ing po
known
call to

The
recipr
betwe

Ma
betwe
vidua
gresse
tive g
night
All
plexu
site. S
eggs,

knowledge of the biology of this form permits an experimental inquiry into the relationships of the different populations.

Hyla versicolor as presently known is a moderate-sized treefrog which ranges through eastern North America from the southern portions of the Canadian provinces to northern Florida and west to the central states where the more xeric prairie habitat apparently limits its distribution. The external morphology is known to be quite variable even between individuals of local populations.

The taxonomic history began with the original description by Le Conte (1825). Cope (1880) described *Hyla femoralis chrysoscelis*, and Strecker (1910) reassigned the form as *H. versicolor chrysoscelis*. Cope (1889) described *H. v. phaeocrypta*. The latter has been confused with *versicolor* and a frog that Viosca (1928) described as *H. avivoca*. Smith (1953) presented evidence that *phaeocrypta* is a synonym of *versicolor*. The latest addition to the nomenclature was the description of *H. versicolor andersi* (Smith and Brown, 1947). All of the work centered around the variation of the color pattern and texture of the skin.

The existence of call-types in *H. versicolor* has been recognized since Noble and Hassler (1936) noted the phenomenon in Maryland and suggested that the call-types represented geographic races. Walker (1946), Hoffman (1946), and Mittleman (1947) have reported differences in call-types from Ohio, Virginia, and Indiana. The calls were variously described as "harsh" and "mellow." Blair (1958) has analyzed the call-types by the sound spectrogram, and his data show a fast trilling population in central Texas and a slow trilling population in southeast Texas, with two known overlap stations. He has shown the call to be genetically determined.

The Texas populations were used to make reciprocal crosses and to test hybrid viability between call types.

METHODS

Material for artificial crosses was collected between March and May of 1958. All individuals used were taken from breeding congregations and are assumed to have been in active gametogenesis. Collections were made at night with the aid of a head lantern.

All females used were taken while in amplexus or as they approached the breeding site. Such females already possessed oviducal eggs, and so no induced breeding was at-

tempted. Females once collected were transported in single glass containers to the laboratory. They were kept in a portable ice box to prevent oviposition in route where long distances were traveled.

Breeding individuals of the western call-type were taken at two stations. One was 29 miles east of Austin, Texas, on state road 969. The other was 8 miles east of Bastrop, Texas, near highway 21. Eastern call-type material was taken from four stations between Richards and Diboll, Texas. These were 11 miles east of Richards on state road 149, 15 miles southwest of Huntsville on state road 1791, 11 miles east of Livingston on U. S. highway 190, and 6 miles south of Diboll on highway 59. These stations are all within the allopatric range of the call-types as shown by Blair (*op. cit.*). The call-types are distinguishable by ear in the field.

A zone of overlap occurs approximately 10 miles east of Bastrop, Texas, on park road 1 between Bastrop and Buescher state parks, Blair (*op. cit.*). Both call-types were collected here calling from the same breeding sites.

Artificial crosses were made as described by Rugh (1948). Sperm suspensions were prepared in 10 cc. of aged tap water. Each suspension was made from both testes and was allowed to stand 5-8 minutes before eggs were introduced. Eggs were stripped directly into these suspensions so that each egg was exposed as much as possible. The suspension was immediately pipetted over the eggs as an extra precaution. The control suspensions were alternately given the first and last eggs from a female to check on differential fertility of eggs from the posterior and more anterior portions of the oviduct, and on the viability of the sperm over the time interval used. The crosses were shortly flooded with the conditioned water and the eggs separated to aid in respiration.

The data have been interpreted on the following four assumptions:

- (1) An excess of viable sperm was present at fertilization.
- (2) All oviducal eggs were equally capable of fertilization.
- (3) The incidence of exogastrulation was not environmentally induced.
- (4) All individuals were typical of their respective populations.

Control crosses made at the upper and lower limits of the time interval for the standing sperm suspensions have shown no significant deviation. Control crosses made of eggs from the posterior and more anterior

portions of the oviduct have been comparable. The difference in the incidence of exogastrulation between experimental and controls, for the latter in all but two cases being zero, gives strong support for assuming the abnormality was not the result of an environmental factor. These assumptions appear reasonably safe.

Percent fertilization was taken from the total number of eggs per cross. Percent exogastrulation was taken from the total number of eggs fertilized. Every egg so considered died with a definitely unenclosed yolk plug.

A chi-square test was used to measure the significance of the difference in fertilization frequency between the experimental and control crosses. The observed value of the control cross for each experimental cross was taken as the expected in the latter. Since χ^2 is calculated from percentages, the value must be multiplied by $n/100$, n being the total number of individuals counted, before applying the value to a probability table. χ^2 values for between call-type crosses were significant at the .01 confidence level. Statisti-

cians accept probabilities less than 0.05 as significant.

The larvae were raised in enamel trays and fed boiled lettuce leaves. Detritus was drawn off with a pipette and clean, aged water added as required.

A daily record of mortality was obtained for each cross until metamorphosis. The data were analyzed by calculating the cumulative percent mortality per day for days after hatching for each cross and the averages for each reciprocal combination.

The number of experimental eggs and embryos was rapidly reduced during the first seven days to approximately 20 individuals per culture tray. This density has produced no noticeable effect on growth. The mortality of the controls was very small in comparison, and crowding effects would have been quickly felt, for as many as 100 individuals remained per tray. Therefore, 20 of each control cross were chosen at random on the tenth day and the others discarded.

EASTERN FEMALE \times WESTERN MALE CROSSES

Twelve experimental crosses of this combination were made from material collected away from the overlap zone. Four experimental males and one control male were used per female. The number of eggs, number of eggs fertilized, number of exogastrulae, percent fertilization, and percent exogastrulation per cross are shown in Table 1. The differences in the frequency of fertilization between experimental and control crosses were statistically significant for each cross as shown by the chi-square test.

The fertilization in the control crosses ranged from 67.3 to 78.9 percent and averaged 72.6. The range in the experimental crosses was 30.5 to 52.7 percent, and the average was 40.6. The number of exogastrulae was surprisingly high. All experimental crosses showed this phenomenon. The range of exogastrulation was 14.3 to 34.4 percent, and the average was 25.3 percent. In this series of crosses no exogastrulae occurred in the controls. The average cumulative percent dead per day for days after hatching until metamorphosis is shown in Figure 2. The high rate of mortality between the fourth and seventh days occurred in all of the experimental crosses.

WESTERN FEMALE \times EASTERN MALE CROSSES

Twelve experimental crosses of this combination were made with material from out-

TABLE 1

FERTILIZATION AND EXOGASTRULATION DATA FOR
EACH CROSS OF THE EASTERN \varnothing WESTERN σ
COMBINATION

The chi-square values test significance of the difference in fertilization frequency between experimental and control crosses. For method of calculating chi-square, see text.

Number of eggs	Fertilization			Exogastrulation	
	Number	Percent	χ^2	Number	Percent
75	24	32.0	18.5	6	25.0
125	52	41.5	9.8	13	25.0
73	28	38.3	12.4	7	25.0
92	40	43.4	8.4	12	30.0
134*	90	67.3		0	0
89	40	43.9	10.7	9	22.5
122	48	39.3	14.6	11	22.9
72	22	30.5	23.6	5	22.7
55	29	52.7	5.0	6	20.7
71*	51	71.7		0	0
92	34	36.9	23.6	11	32.3
62	28	45.1	14.4	4	14.3
79	27	34.1	25.4	8	29.6
58	29	50.0	10.5	10	34.4
57*	45	78.9		0	0

* Control crosses.

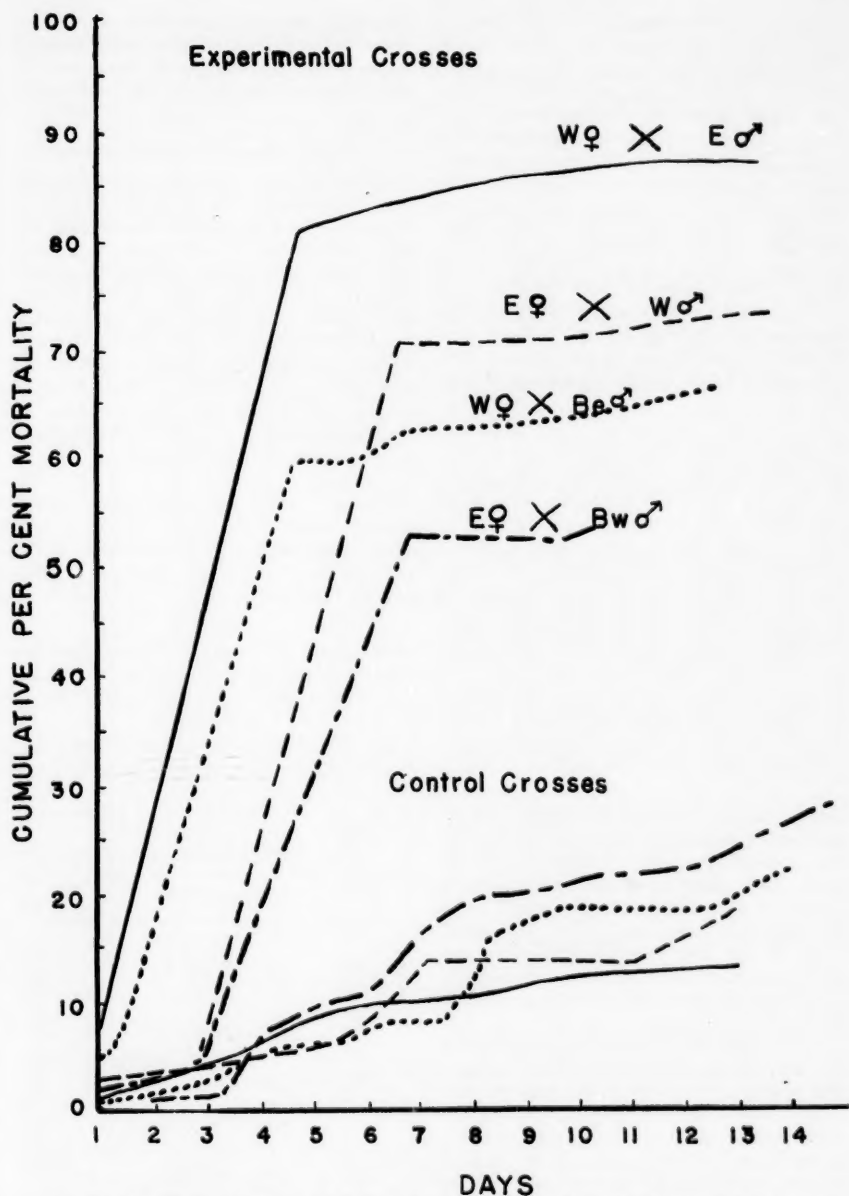


Fig. 2.—Average cumulative percent mortality per day for days after hatching for between call-type crosses outside of the overlap zone and of between call-type crosses involving males from the overlap zone for comparison.

TABLE 2
FERTILIZATION AND EXOGASTRULATION DATA FOR
EACH CROSS OF THE WESTERN ♀ EASTERN ♂
COMBINATION

Number of eggs	Fertilization			Exogastrulation	
	Number	Percent	χ^2	Number	Percent
202	91	45.0	29.6	14	15.3
190	62	32.6	23.6	9	14.5
193*	14.4	74.6		0	0
85	33	38.8	12.7	7	21.2
180*	123	68.3		0	0
112	24	21.4	33.8	5	20.8
97*	68	70.1		0	0
116	31	26.7	21.2	3	9.6
168	79	47.0	4.4	25	31.6
217	39	17.9	32.6	11	28.2
238*	151	63.4		4	2.6
168	12	7.1	62.6	4	33.3
280	65	23.2	38.1	15	23.0
264	106	40.1	17.1	23	21.6
216	105	48.6	9.9	15	14.2
80*	61	76.2		0	0
122	39	31.9	18.3	7	17.9
103*	69	66.9		0	0

* Control crosses.

side of the overlap zone. The number of experimental males per female is variable for this combination since gravid western females were easier to obtain over a longer period of time. Survival data for this series of crosses are shown in Table 2. The differences in the frequency of fertilization between experimental and control crosses are statistically significant for each cross as shown by the chi-square test.

The control crosses showed a range of 63.4 to 76.2 percent fertilization and averaged 69.5 percent. The range in the experimental crosses was 7.1 to 48.6 percent, and the average was 30.0 percent. The incidence of exogastrulation was substantial in the experimental crosses. All experimental crosses showed this abnormality. The experimental crosses ranged from 9.6 to 33.3 percent and averaged 20.9 percent. One control cross did show 2.6 percent exogastrulation, but the respective experimental crosses showed 9.6, 31.6, and 28.2 percent. The average cumulative mortality data are shown in Figure 2.

The steep part of the mortality curves comes between the second and fifth days. This steepening of the curve is not the result of averaged data, but occurred in all experimental crosses.

CROSSES FROM THE OVERLAP ZONE

Males of both call-types were available from the overlap station east of Bastrop, Texas. In the following discussion these symbols will be used: Bw♂, western call-type male from the overlap station, and Be♂, eastern call-type male from the overlap station. These were crossed with females from respectively east and west of the overlap zone to give combinations between and within call-type populations. The control was a cross of each female used with a male of her respective call-type. It is presently impossible to distinguish between females in the overlap zone.

Crosses within call-types.—Four experimental crosses of the eastern female X Be♂ were made using two experimental crosses per control. Comparable data on fertiliza-

TABLE 3
FERTILIZATION AND EXOGASTRULATION DATA FOR
EACH CROSS INVOLVING MALES FROM THE
OVERLAP ZONE FOR WITHIN CALL-TYPE
CROSSES

Bw♂ and Be♂ refer to western and eastern call-type males respectively from the overlap zone.

Number of eggs	Fertilization			Exogastrulation	
	Number	Percent	χ^2	Number	Percent
Eastern ♀ X Be ♂					
63	36	57.1	1.7	0	0
45	29	64.4	0.2	0	0
69*	47	68.1		0	0
40	28	70.0	1.2	0	0
46	28	60.8	0.008	0	0
72*	44	61.1		0	0
Western ♀ X Bw ♂					
94	64	68.1	0.1	0	0
86	61	70.9	0.5	1	1.6
54*	35	64.8		0	0
115	75	65.2	0.1	0	0
78	50	64.0	0.2	0	0
89*	61	68.5		0	0

* Control crosses.

tion a
above
ferenc
tween
not sta

The
percent
cent.
tween
63.0 p
in eith
averag
are sh
Fou
female
exper
data :

5
4
3
2
CUMULATIVE PER CENT MORTALITY

F
call-

tion and exogastrulation as shown for the above crosses are given in Table 3. The differences in the frequency of fertilization between experimental and control crosses were not statistically significant.

The control crosses showed 61.1 and 68.1 percent fertilization and averaged 64.6 percent. The experimental crosses ranged between 57.1 and 70.0 percent and averaged 63.0 percent. No exogastrulae were observed in either experimental or control crosses. The average cumulative percent mortality data are shown in Figure 3.

Four experimental crosses of the western female X Bw♂ were made, also using two experimental crosses per control. Survival data are shown in Table 3. The difference

in frequency of fertilization between experimental crosses was not statistically significant.

The control crosses showed 64.8 to 68.5 percent fertilization and averaged 66.6 percent. The experimental crosses ranged between 64.0 and 70.9 percent fertilization and averaged 67.0 percent. One experimental cross did show 1.6 percent exogastrulation. No exogastrulation occurred in the controls. The average cumulative percent mortality is shown in Figure 3.

Crosses between call-types.—Three experimental crosses of the eastern female X Bw♂ were made. Survival data for experimental and control crosses are given in Table 4. The difference in frequency of fertilization

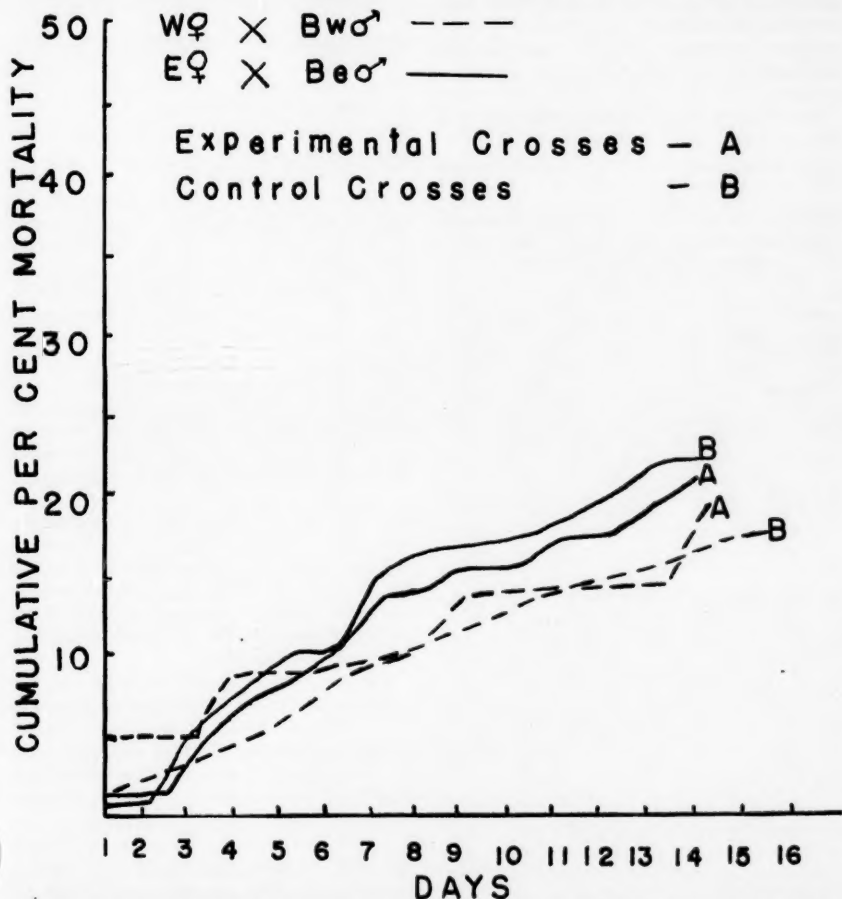


Fig. 3.—Average cumulative percent mortality per day for days after hatching for the within call-type crosses from the overlap zone.

between experimental and control crosses was statistically significant.

The control crosses showed 71.2 and 73.7 percent fertilization and averaged 72.4 percent. The experimental crosses had a range of 31.3 to 38.8 percent and averaged 34.3 percent. Exogastrulation was observed in all three experimental crosses. The exogastrulation had a range of 22.5 to 34.3 percent and averaged 28.4 percent. There were no exogastrulae in the controls. The average cumulative percent mortality data are shown in Figure 2. There was a high death rate between the fourth and seventh days with mortality practically over after the seventh day.

Four experimental crosses of the western female X Bw♂ were made using two experimental crosses per control. Survival data are shown in Table 4. The difference in fertilization frequency between experimental and control crosses was statistically significant as shown by the chi-square test.

The control crosses showed 66.6 and 74.6 percent fertilization and averaged 70.6 per-

TABLE 4
FERTILIZATION AND EXOGASTRULATION DATA FOR
EACH CROSS INVOLVING MALES FROM THE
OVERLAP ZONE FOR BETWEEN
CALL-TYPE CROSSES

Bw ♂ and Be ♂ refer to western and eastern call-type males respectively from the overlap zone.

Number of eggs	Fertilization			Exogastrulation	
	Number	Percent	χ^2	Number	Percent
Eastern ♀ X Bw ♂					
102	32	31.3	22.3	11	34.3
103	40	38.8	14.7	9	22.5
87*	62	71.2		0	0
85	28	32.9	22.5	8	28.5
91*	67	73.7		0	0
Western ♀ X Be ♂					
77	31	40.2	10.4	13	41.9
71	15	21.1	31.0	5	33.3
81*	54	66.6		1	1.8
69	30	43.4	13.1	8	26.6
78	25	32.0	24.3	7	28.0
63*	47	74.6		0	0

* Control crosses.

cent. The experimental crosses had a range of 21.1 to 43.4 percent fertilization and averaged 34.1 percent. Exogastrulation was present in all experimental crosses. The exogastrulation range was 26.6 to 41.9 percent, and the average was 32.4 percent. One control cross had 1.8 percent, while the respective experimental crosses showed 41.9 and 33.3 percent. The steep part of the mortality curve shown in Figure 2 occurred between the second and fifth days, and the trend was present in all four of the experimental crosses.

DISCUSSION

The percent fertilization and frequency of exogastrulation for crosses between call-type were found to be comparable for material outside of and within the overlap zone. These crosses differed significantly from the control crosses. The crosses within call-types from the overlap zone were comparable to their control crosses and to the other within call-type control crosses.

No data are available for the percent fertilization achieved in nature. Rugh (*op. cit.*) states that *Hyla versicolor* lays eggs in clusters of 50 with a total of one to 2,000. This author states that *H. crucifer* inseminates each egg as laid. Such data are not known for *H. versicolor*, and the observed fertilization values have no field observations for comparison.

The survival to metamorphosis in all crosses between call-types was much lower than in the control crosses. The two combinations involving crosses between call-types have shown different mortality curves. The eastern female X western call-type males had high mortality between the fourth and seventh days, and the western female X eastern call-type males had similar mortality between the second and fifth days. The mortality curves are similar in this respect for the above reciprocal combinations both within and outside of the overlap zone.

The combined data for lower percent fertilization, higher percent exogastrulation, and lower survival rates for all experimental combinations involving different call-types than for their control crosses suggest a rather high degree of genetic incompatibility between the two forms.

A wide spectrum of expression of inviability exists at this stage of the life history. Namely, some eggs appear to completely re-

sist in
a high
second
still of

The
probab
which
genoty
are no
differ
specti
latitud
volved
found

Blai
ses co
The C
fragm
the P
inviab
sympa
conclu
of seco

The
popul
having
as yet
viving
pholo
rate th

Tw
found
presse
morta

Th
the F
contr

Th
as an
Pleist

Th
acting

LA
PHIL
163-4
one o
certa

sist insemination, others fail at gastrulation, a high larval mortality occurs during the second to seventh days after hatching, and still others successfully metamorphose.

These different stages of the F_1 failure are probably the expression of hereditary factors which are not all present in every individual genotype. This would suggest that the factors are not closely linked if at all. However, the different mortality patterns for the two respective genotypes have been consistent. No latitudinal adaptation appears to be involved here as Moore (1939, 1942, 1949) has found for the genus *Rana*.

Blair (1958) has given the possible hypotheses concerning the origin of the call-types. The Gulf Coast is an area where population fragmentation has probably occurred during the Pleistocene. It is inconceivable that the inviability found could have originated in sympatric populations which leads to the conclusion that the overlap zone is an area of secondary contact.

The available data suggest that the two populations sampled in this study are behaving as two separate species. No data are as yet available on the backcross of the surviving F_1 's to the parental forms. No morphological criteria are as yet known to separate the two forms.

SUMMARY

Two call-types of *Hyla versicolor* were found to be correlated with F_1 inviability expressed in fertilization, exogastrulation, and mortality prior to metamorphosis.

The different stages of the mortality of the F_1 hybrids are considered to be genetically controlled by various hereditary factors.

The zone of overlap in Texas is interpreted as an area of secondary contact as a result of Pleistocene separation of the species range.

The two call-types in Texas appear to be acting as good species.

LITERATURE CITED

- BLAIR, W. FRANK. 1958. Mating call in speciation of anuran amphibians. *Amer. Nat.* 92:27-51.
- COPE, E. D. 1880. On the zoological position of Texas. *U. S. Nat. Mus. Bull. No. 17.* 51 pp.
- . 1889. The Batrachia of North America. *U. S. Nat. Mus. Bull. No. 34.* 525 pp.
- HOFFMAN, R. L. 1946. The voice of *Hyla versicolor* in Virginia. *Herpetologica* 3:141-2.
- LE CONTE, J. 1825. Remarks on the American species of the genera *Hyla* and *Rana*. *Annals Lyc. Nat. N. Y.* 1:278-82.
- MITTELEMAN, M. B. 1947. Miscellaneous notes on Indiana amphibians and reptiles. *Amer. Midl. Nat.* 38:466-84.
- MOORE, JOHN A. 1939. Temperature tolerance and rates of development in the eggs of amphibians. *Ecology* 21:459-78.
- . 1942. The role of temperature in speciation of frogs. *Biol. Symposia* 6:189-213.
- . 1949. Geographic variation of adaptive characters in *Rana pipiens* Schreber. *Evolution* 3:1-24.
- NOBLE, G. K., AND C. HASSLER. 1936. Three Salientia of geographic interest from southern Maryland. *Copeia* 1936(1):63-4.
- RUGH, ROBERTS. 1948. Experimental Embryology. Burgess Publ. Co., Minneapolis. vii + 480 pp.
- SCHMIDT, KARL P. 1953. A Check List of North American Amphibians and Reptiles. Sixth Edition. *Amer. Soc. Ichthyologists and Herpetologists.* viii + 280 pp.
- SMITH, HOBART M., AND BRYCE C. BROWN. 1947. The Texan subspecies of the treefrog, *Hyla versicolor*. *Proc. Biol. Soc. Wash.* 60:47-50.
- SMITH, PHILIP W. 1953. A reconsideration of the status of *Hyla phaeocrypta*. *Herpetologica* 9:169-73.
- STRECKER, J. K. 1910. Description of a new solitary spadefoot (*Scaphiopus huerterii*) from Texas, with other herpetological notes. *Proc. Biol. Soc. Wash.* 23:115-22.
- VIOSCA, P. 1923. Notes on the status of *Hyla phaeocrypta* Cope. *Copeia* 1923(122):96-9.
- . 1928. A new species of *Hyla* from Louisiana. *Proc. Biol. Soc. Wash.* 41:89-92.
- WALKER, CHARLES F. 1946. The amphibians of Ohio. Part 1. The frogs and toads (order Salientia). *Ohio State Mus. Sci. Bull.* 1(3):1-109.

DEPARTMENT OF ZOOLOGY, THE UNIVERSITY OF TEXAS, AUSTIN, TEXAS.

Herpetological Notes

LACERTA COLONY STILL EXTANT AT PHILADELPHIA.—Kauffeld (*Copeia* 1931(4): 163-4) reported the establishment of a colony of one of the European members of the genus *Lacerta* in a small tract of land adjacent to the

Pennsylvania Railroad plexus of tracks a few squares from the Philadelphia Zoological Garden. Several specimens, imported by an animal dealer, managed to escape from his cages during the summer of 1927, and by the spring of 1931

it was strongly evident that the lizards had prospered and were breeding. Kauffeld, in addition to finding specimens himself, including a half-grown one, learned that they had invaded a nearby lumber yard and were "very numerous in the piles of lumber during the summer months." He identified them, with some hesitation, as *Lacerta melisellensis fumana* Werner.

Shortly after becoming affiliated with the Philadelphia Zoo in 1935, I paid the first of several fruitless visits to the locality. Workers in the lumber yard reported seeing lizards occasionally for several years, but, by the late 1940's, circumstantial evidence indicated that the colony probably had died out. That this assumption was incorrect was attested by the finding of several specimens in the summer of 1958.

The first of these, an adult female minus most of its tail, was brought to the Zoo on July 23, 1958, by Myron Goldberg and several other small boys immediately after the lizard's capture. This specimen, which had a head-body length of 58 mm., deposited three eggs on July 27. The eggs, all adherent to one another, measured 11.5×7.2 , 12.3×7.6 , and 11.5×7.2 mm., respectively; collectively they weighed 1.1 grams. Two of these eggs hatched on September 1, and the young emerging from them had head-body lengths of 26.5 and 27.5 mm.; their total lengths were 74 and 80 mm., and each weighed approximately one-half gram.

Young Goldberg and his associates caught four hatchlings between August 22, and September 3, inclusive, the head-body lengths of which varied from 26 to 28 mm.; all of these had lost most of their tails during capture, and two were so badly injured that they died soon after their arrival at the Zoo. Stern curatorial warnings against further decimating the colony plus the ire of the lumber yard management on the subject of trespassing failed to dampen boyish enthusiasm, but the re-opening of school accomplished the desired end. The lizard colony, which has now survived in Philadelphia for more than thirty-one years, doubtless has been subject to attrition by small boys on many previous occasions.

The adult and several young were dispatched to the Senckenbergische Naturforschende Gesellschaft, Frankfurt-am-Main, and Dr. Robert Mertens, of that institution and an acknowledged expert on lacertids, has identified them as *Lacerta sicula campestris* (Betta). Dr. Mertens (in correspondence) states that this form is easy to confuse with *L. melisellensis* because of the similarity in pattern.—ROGER CONANT, Zoological Society of Philadelphia, Philadelphia 4, Pennsylvania.

OBSERVATIONS ON THE FEEDING BEHAVIOR OF A CAPTIVE ROSY BOA, *LICHANURA ROSEOFUSCA*.—In June of 1958, I received a young rosy boa, *Lichanura roseofusca*, through the courtesy of Delmar E. Mangum and Dr. Richard B. Loomis of Long Beach State College. The specimen was collected in May of the same year at Snow Creek Canyon, Riverside County, California. At present the specimen is 57 cm. long.

The specimen has been fed young laboratory rats (wt. 7-9 grams) at intervals ranging from three to four weeks. Usually three young rats are placed in the cage at each feeding. Rats are normally taken one at a time and constriction is by the anterior one-third of the body. However, in the course of such "normal" feedings another pattern was observed.

On one occasion when the snake was in the process of constriction, a second young rat happened to come in contact with the posterior end of the animal, in the region of the vent, and attempted to crawl over the snake. The snake immediately brought its tail over the rat in a partial coil, then completed the coil from posterior to anterior. Meanwhile anterior constriction continued without apparent interruption. The first rat was devoured while posterior constriction was in progress and the second rat was not released until the snake had firmly grasped the animal in its jaws. This same pattern was observed to occur on a second occasion. Subsequently, this behavior has been induced several times by placing a young rat either against or on the posterior end of the snake while it is in a "normal" anterior constriction. An interesting point is that the snake does not always eat the second rat immediately but rather will seek out a third while still constricting the second. Attempts to induce a triple constriction have been unsuccessful.

Jameson (*Copeia* 1956(1):54-55) reported dual constriction in a Trans-Pecos rat snake (*Elaphe subocularis*) and in a Great Basin gopher snake (*Pituophis catenifer deserticola*). However, dual constriction by these species differed from that of the rosy boa in that each of the two mice was first subjected to anterior constriction.

Such behavior would appear to have adaptive value, at least in the rosy boa, during litter predation and possibly also under other circumstances.—DON R. MEDINA, Museum of Vertebrate Zoology, University of California, Berkeley 4, California.

LONGEVITY OF SNAKES IN THE UNITED STATES AS OF JANUARY 1, 1959.—In the list below only the maximum record for each species or subspecies is given. The age of each snake is

given in column fourth snake included died having be inc ested i living United 1955(3) as of apprec record Symbc Zoo, J Caroli SDZ =

Aghistr
Aspis c
Crotalus
Crotalus
Crotalus
Drymar
Epicrat
Lampro
Lampro
Loxocen
Ophioph
Pituoph
Pituoph
cus*
Pituoph
Python
Python
Python
Rhinoc

CHARI
P. O.

NO
TRAC
made
fluid
semys
pipets
man i
man
requi
matec
was i
electr
Th
12 to
gin. A
separ
contr

given in years (second column) and months (third column), with the source of the record in the fourth column. An asterisk indicates that the snake was alive on January 1, 1959. This list includes only individuals still alive or those that died during the previous year. Snakes noted as having died during the preceding year will not be included in subsequent lists. Those interested in the most recent complete list of snakes living ten years or more in collections in the United States are referred to Perkins (*Copeia* 1955(3):262). This list will be brought up to date as of the first of January each year. We would appreciate hearing from anyone having longer records, or ten-year records for other species. Symbols used are as follows: BdZ = Brookfield Zoo, JGM = John G. Moore, NCM = North Carolina State Museum, PZ = Philadelphia Zoo, SDZ = San Diego Zoo.

<i>Agkistrodon contortrix laticinctus</i> *	18	7	SDZ
<i>Aspis cerastes</i> *	11	5	SDZ
<i>Crotalus adamanteus</i> *	15	1	SDZ
<i>Crotalus atrox</i> *	22	2	SDZ
<i>Crotalus horridus atricaudatus</i>	11	11	NCM
<i>Crotalus viridis viridis</i>	19	3	SDZ
<i>Drymarchon corais couperi</i>	25	11	JGM
<i>Epicrates angulifer</i> *	20	2	SDZ
<i>Lampropeltis doliaia triangulum</i> *	13	9	PZ
<i>Lampropeltis getulus holbrooki</i> *	15	8	SDZ
<i>Loxocemus bicolor</i> *	16	0	PZ
<i>Ophiophagus hannah</i> *	12	4	PZ
<i>Pituophis catenifer deserticola</i>	10	11	SDZ
<i>Pituophis melanoleucus melanoleucus</i> *	18	5	SDZ
<i>Pituophis melanoleucus mugitus</i> *	12	11	BdZ
<i>Python curtus curtus</i> *	22	10	SDZ
<i>Python molurus bivittatus</i> *	22	9	SDZ
<i>Python regius</i> *	13	9	PZ
<i>Rhinocheilus lecontei lecontei</i> *	17	1	SDZ

CHARLES E. SHAW, Zoological Society of San Diego,
P. O. Box 551, San Diego 12, California.

NOTES ON THE pH OF THE DIGESTIVE TRACT OF *CHRYSEMYX PICTA*.—A study was made of the hydrogen-ion concentrations of the fluid in the digestive tract of the turtle, *Chrysemys picta*. Samples of fluid were taken with pipets and pH was determined by using a Beckman Model G pH meter, equipped with a Beckman 40316 "one-drop" glass electrode, which requires only 0.5 ml. of fluid. The pH was estimated with LaMotte pH Test Papers when there was insufficient fluid for the "one-drop" glass electrode.

The turtles used were fairly uniform in size, 12 to 13 cm. shell length and weighed 300 to 400 gm. Animals for experimentation were arbitrarily separated into four groups: *Group I*, nine fed controls, maintained in terraqueous tanks at

room temperature, 22° to 27° C; *Group II*, 14 animals, fasted for 1 to 4 weeks and maintained in tanks comparable with the controls; *Group III*, three cold-exposed and fasted animals, maintained in water and refrigerated at 5° C for two weeks; and *Group IV*, eight cold-exposed specimens which were force-fed about 3 grams of raw horsemeat once during their two-week exposure. The horsemeat was gently pushed down the throat of the torpid specimen. The meat was found to have a pH of about 6.

Four sites were selected for study: 1) stomach, 2) upper small intestine, 5 to 20 cm. from pylorus, 3) middle small intestine, 20 to 40 cm. from pylorus, and 4) lower intestine, 40 to 60 cm. from pylorus. The stomach was separated from the rest of the enteron by ligation, thus, during the examination procedures, there was no mixing of fluids of the stomach and small intestine.

Seven days after being placed in the refrigerator at 5° C, four turtles of *Group IV* were removed and force-fed. This took but a few minutes and they were returned to the refrigerator. Fifteen days after initial exposure, the four other turtles were force-fed and returned to their cold environment. This was done in order to evaluate the effects of cold torpor on digestive processes.

Observations and discussion.—The fact that the turtles were maintained in an aquatic medium precluded any measure of oral pH. The pH test papers were used on the moist esophageal surface of specimens from each group and the range in pH was from 7 to 9. The conditions of the experiment apparently had little or no effect on the pH of the esophagus. Further examination showed that the esophagus has ciliated epithelium and compound tubular glands, presumably for secretion of mucous material which aids in movement of food. Carbon particles placed on the ciliated epithelium of one specimen were moved toward the stomach.

The results are summarized in Table 1.

Group I (fed "control" turtles).—The stomach contents of recently fed animals were found to be acidic. The partially digested food mass, fluids or mucus present had a range of pH of 2.2 to 4.0 (with the Beckman) and 2.0 to 6.0 (with test papers). These data are comparable to those obtained (Wright, *et al.*, *Quart. Jour. Exper. Physiol.* 42:1, 1957) in studies of the tortoise, *Testudo graeca*. In the tortoise, the mucous fluid of the stomach was at pH 2, and food at the point of contact with the mucosa was pH 3.

The intestinal fluids of *C. picta* examined with the Beckman instrument were found to be most alkaline in the middle portion of the tract, pH 7.3 to 8.3. The pH of undigested material in the lower intestine was often more acidic than that

TABLE 1
HYDROGEN-ION CONCENTRATION (pH) OF DIGESTIVE ORGANS OF COLD AND WARM TURTLES,
Chrysemys picta

Range of pH Values of Fluids at Four Different Sites in Digestive Tract as Determined by Two Methods. Figures in Parentheses Following pH Ranges Represent Numbers of Analyses Made

Conditions of specimens	Method	Stomach	Upper intestine	Mid-intestine	Lower intestine
Group I (9 turtles) fed W ¹	E ²	2.2-4.0 (4 analyses)	7.0-7.5 (2 analyses)	7.3-8.3 (4 analyses)	6.6-7.5 (4 analyses)
	P ²	2.0-6.0 (5)	.....	8.0-8.5 (5)	.....
Group II (14 turtles) fasted W ¹	E	5.3-7.5 (4)	6.5-8.9 (4)	6.3-8.5 (5)	7.1-8.5 (5)
	E	1.8 & 2.1 (2)*	.....	.....	.....
	P	6.5-8.0 (8)	.....	8.0 (8)	.....
Group III (3 turtles) fasted C ¹	P	7.0-8.0 (3)	7.0-8.0 (3)	7.0-8.0 (3)	7.0-8.0 (3)
	P	7.0-8.0 (3)	7.0-8.0 (3)	7.0-8.0 (3)	7.0-8.0 (3)
Group IV (8 turtles) force-fed C ¹	E	5.8-7.6 (5)	6.4-7.2 (2)	.....	7.0-7.6 (5)
	P	6.0-8.0 (8)	7.0-8.0 (4)	7.0-8.0 (8)	7.0-8.0 (3)

¹W = Warm, room temperature of 22-27°C; C = Cold-exposed, 5°C.

²E = Beckman "one-drop" glass electrode method; P = LaMotte pH test papers.

*1.8 = cardiac sample, 2.1 = pyloric sample.

in the upper or middle portions of the small intestine.

Group II, Fasting turtles.—The stomach contents of fasting turtles varied considerably both in fluid content and pH. The high stomach pH values ranged from 5.3 to 7.5 (glass electrode method) and 6.5 to 8.0 (pH test papers), and characteristic of these stomachs was the paucity of fluid matter. By way of contrast, two turtles had considerable amounts of clear fluid in the stomach and the pH was highly acidic, pH 1.8 (Table 1). From these two turtles, fluid samples were taken from cardiac and pyloric regions. The cardiac fluid was found to be more acidic than the pyloric fluid. It is of some note that Wright *et al.* (*op. cit.*) also found that in *Testudo* the mucosa of an empty stomach has a pH of from 7.5 to 8.0. The pH of fluid contents of all intestinal regions in this group was near neutrality or decidedly basic. The *upper* portions ranged from pH 6.5 to 8.9; *middle* regions from 6.3 to 8.5, and the *lower* intestinal contents were in a range from 7.1 to 8.5.

Group III (cold and fasting turtles).—In these animals the entire digestive tract was devoid of food and contained little or no fluid. The walls of the esophagus, stomach and intestine had a narrow range in pH, from 7.0 to 8.0 (Table 1). By way of comparison, the fasting animals at room temperature have a much wider range in pH in all areas of the enteron. These results reflect the magnitude of the effects of low temperatures in the restriction of some processes of digestion.

Group IV (cold and fed turtles).—The esophagus, stomachs, and intestines of these turtles were examined at 2, 4 and 10 days after forced feed-

ing. The pH of the esophagus, 7.0 to 9.0, was measured with the test papers in eight specimens. Specimens examined from 2 to 4 days were found to have large distended stomachs, the content of which was a large bolus of undigested horse meat coated and partially mixed with a viscous fluid. The surface of these food boli had a pH of from 7.0 to 8.0; the viscous fluid was found to have a slightly lower pH of 6.5 to 7.6. The stomach viscous secretions are therefore more acidic than the food; this suggests that the food which has passed through the alkaline lumen of the esophagus has not been acted on by the stomach secretions. These observations serve to strengthen the position that the low body temperature severely affects the production of stomach hydrochloric acid. The intestines were empty and the pH test papers which were placed against the walls showed a pH of 7.0 to 8.0 in all three loci.

Ten days after feeding, large undigested food masses remained in the stomach or intestine, or both. Active peristalsis was observed in several of these cold-exposed turtles with body temperatures about 5° C. In two of these animals the food had been propelled to the lower part of the intestinal tract, within eight centimeters of the anal end. Small amounts of viscous fluid in the stomachs showed a pH of 5.8 and 7.6. The moist wall showed a pH of 7.0 and 8.0 with indicator papers. The surface of the undigested food masses in the stomach had a pH of 6.0 or 7.0. The food masses found in the upper or lower intestines of these animals showed that little or no digestion had taken place. The surfaces of these intestinal food masses had a pH of 7.0 to 7.6.

General.—From these studies one may deduce that, in *Chrysemys picta* at room temperatures,

the pH of the stomach "at rest" is close to neutrality and becomes acidic following the stimulus of food ingestion. Peristaltic waves move the food mass through the stomach slowly toward the intestine through a pyloric sphincter. In the intestine an alkaline pH is rapidly attained as the food mixes with pancreatic secretions and bile.

In a few specimens, bile taken directly from the gall bladder was found to have a pH value of 7.5. Animals in cold torpor do not appear to secrete any acid from the stomach wall, nor does intestinal digestion go on, although peristalsis still occurs. Thus it may be argued that cold temperatures inhibit chemical digestive processes in this animal.

Finally, a comment may be made about the length of time food remains in the digestive tract of this species after a meal. Dissections 24 hours after feeding disclosed food still present in the stomach of animals kept at room temperature. Seven days after a meal, semi-liquid food material was found in the middle section of the intestine, but the stomach contained only mucus and clear fluid. Propulsion of the food mass was slowed down in cold torpid turtles. In four of the cold force-fed animals, the food was still retained in the stomach 3 to 4 days after feeding. Ten days after force-feeding 2 animals still retained some food in the stomach. However, all 4 of these turtles had food masses in the lower intestine. The food mass, in the torpid animals, was frequently semi-solid. The texture was comparable to its condition before feeding. In the lower portions of the digestive tract, there was obvious addition of viscous mucoid matter, but the food was undigested. One may conclude, therefore, that peristalsis goes on at a reduced rate, and chemical digestion is, for all practical purposes, inoperative in turtles exposed to periods of low temperatures.—SISTER ALICE MARIE FOX, B.V.M. AND X. J. MUSACCHIA, *Biology Department, Saint Louis University, St. Louis, Missouri*.

OBSERVATIONS ON THE NESTING HABITS OF THE MUDPUPPY, *NECTURUS MACULOSUS* RAFINESQUE.—A field search for living embryos of *Necturus* for embryological studies was begun in the spring of 1954 in the vicinity of Ann Arbor, Michigan. Since *Necturus* has been reported as occurring in the Huron River, nests were sought during the months of April and May in the river above (upstream from) Delhi, but without success. Toward the end of May, when it was believed that egg-laying should be well under way, a few lakes in the Chelsea area which have temporary or permanent connections with the Huron were investi-

gated. The first nest was found in North Lake on June 5. It had approximately 80 eggs. The eggs were attached singly to the under side of a large board (about 2 x 15 feet in size) which was submerged in about two feet of water. Later estimates placed the age of these embryos at 22 days, making the date of egg-laying about May 13. Shortly after this time, numerous nests were found in nearby Sugarloaf Lake, and a large series of embryos of from 24 days in age to hatching (34-37 days) was obtained.

In the Spring of 1955, the first eggs were found at Sugarloaf Lake on April 26. Some of the eggs were uncleaved; others were in the two-cell stage. Four days earlier, on April 22, 28 adult *Necturus* were collected with the aid of an electric shocker. These were placed in a large concrete aquarium. Eggs were laid on the under side of galvanized metal sheets by one or more of these animals on the night of April 24.

The clutch size of the nest varied considerably. The number of eggs in 11 nests was found to be: 101, 91, 78, 62, 54, 52, 49, 42, 40, and 28. This gives an average of about 60 eggs per nest, which compares well with the findings of Smith (*Biol. Bull.* 20:191-20, 1911) who reported, in five nests, 87, 84, 80, 61, and 18, with an average of 66. In three nests Bishop (*N. Y. State Mus. Bull.* No. 268, 1926) found numbers of 87, 96, and 140. Bishop quotes Paul Webb as finding nests with from 90 to 180 eggs. The ovaries of three adult females captured in the spring of 1955 were found to contain from 105 to 140 eggs. It is probable that some nests include eggs from more than one female, but most nests appear to contain less than the full complement of eggs of one female.

The April date for egg-laying is rather early compared to the dates for deposition reported by previous workers. Bishop (*op. cit.*) states that the first eggs found in eastern Pennsylvania over a period of five years was during the first week of June. Smith (*op. cit.*) found eggs in Lake Monona, Wisconsin, as early as May 3, but in most years he did not find them until mid- or late May.

One remarkable feature of the nesting habit is the uniformity of the time of ovulation. Although there is probably greater variation among different lakes, all the eggs found in Sugarloaf Lake in 1955 were almost of one developmental age. Egg-laying presumably occurred during the night of April 25, or the day of April 26. In the following weeks of collecting (every two or three days), no new nests (that is, nests with younger embryos) were found.

However, Eycleshymer (*Anal. Anz.*, 25:230-239, 1906) states: "The eggs are first deposited in those localities where the water is shallow and ex-

posed for the greater part of the day to the rays of the sun. The period of egg laying usually covers two or three weeks. There is no foundation whatever for the statement made by Hans Virchow that the animals deposit their eggs so to speak at the same hour." On the other hand, Smith (*op. cit.*) says: "On each of the following dates from four to seven nests were secured: June 22, 25, 29, July 5. On each date all the eggs were found so nearly in the same stage of development that only slight differences could be detected in eggs from different nests. This uniformity points to a very short spawning season—perhaps two or three days—in this locality; it would seem that all the eggs in a restricted area are laid at nearly the same time."

The nests found in Sugarloaf Lake were usually shallow cavities in the bottom sand or marl beneath flat rocks. Clean logs or boards partially buried in the sand also are frequent sites. The eggs are attached to the under surface of the board or rock which forms the cover of the nest. They are deposited singly and are attached by a circular, disk-like expansion of the outer envelope or jelly layer. A man-made situation at Sugarloaf Lake seemed to be ideal. In 1946–47 the Michigan State Department of Conservation placed several hundred large, shallow, wooden boxes filled with gravel in water about 2 to 4 feet deep as spawning sites for largemouth bass. In the summer of 1954 and 1955, the boxes attracted spawning *Necturus*, as I found that they had used about one-fourth of these boxes as nesting sites.

In the summer of 1954, eggs were removed from the boards in the field, brought into the laboratory, and placed in large concrete aquaria, where they settled to the bottom. With this treatment the eggs seemed to hatch about one week prematurely, and the embryos invariably died. In the summer of 1955, the spawning boxes were partly dismantled and the egg-bearing boards were brought back in water-filled milk cans. The mortality rate in these collections was greatly reduced. Presumably, in pulling the eggs away from the boards the jelly membranes are sufficiently ruptured to cause premature hatching.—KENNETH L. FITCH, *Department of Anatomy, College of Medicine, University of Nebraska, Omaha, Nebraska.*

A SYNONYM AND A HOMONYM IN THE FROG GENUS *HYLA*.—While in Cambridge recently, I had the opportunity to study some types, the examination of which permits clarification of the status of two recently proposed names. I am indebted to Dr. Ernest E. Williams of the Museum of Comparative Zoology for permission

to examine these types and to the National Science Foundation for the grant (G-5628) which made travel to Cambridge possible.

Hyla shrevei Taylor equals *Hyla wilderi* Dunn. The type of *H. shrevei* (Taylor, *Breviora* 1:1, 1952) is purported to be from La Loma, Chiriquito, Panama, and these data are on the slip in the jar and in the original entry in the catalogue. *Hyla wilderi* (Dunn, *Occ. Papers Boston Soc. Nat. Hist.* 5:161, 1925) is from Moneague, St. Ann's Parish, Jamaica, B. W. I. Direct comparison of the types (MCZ 26769 and 10500, respectively) of these two species leaves no doubt that these two names were proposed for a single species. When placed side by side, the only apparent difference is that the specimen of *Hyla wilderi* is now a pale tannish brown rather than medium brown as is *Hyla shrevei*. In size and in structural characters, the two specimens are nearly identical and unquestionably are conspecific.

The cause of the original mix-up in the data of *Hyla shrevei* that led Dr. Taylor to describe it as new cannot be ascertained. Knowing of my long interest in Jamaican frogs, Dr. Taylor suggested that I make this synonymic assignment of *shrevei*.

Hyla alleni Goin is preoccupied. When I described *Hyla alleni* from Leticia, Amazonas Comisaria, Colombia (Goin, *Jour. Wash. Acad. Sci.* 47(2):60, 1957) I overlooked the fact that Cope (*Proc. Amer. Philos. Soc.* 1869:162, 1869) had described *Scytotis alleni* from Para, Brazil, and that Barbour and Loveridge (*Bull. Mus. Comp. Zool.* 69(10):338, 1929) had referred this, correctly, to the genus *Hyla*. This action made the combination *Hyla alleni* unavailable for the frog from Leticia, and I propose as a substitute the name *Hyla rossalleni*.

Barbour and Loveridge (*op. cit.*) refer Cope's *alleni* to the synonymy of *Hyla rubra*. While it is, in my opinion, unquestionably a *Hyla*, I am not so confident that it should be referred to *rubra*. I compared it with a series of *rubra* from British Guiana in the Museum of Comparative Zoology (MCZ 26154–56, 7 specimens), which are probably as close to topotypes as we can expect. The two forms seem to be very similar morphologically, but show some striking differences in pattern. The type of *S. alleni* gives the impression of being a spotted frog, while the *rubra* are more uniform except for pale dorsolateral stripes. Furthermore, none of the *rubra* has pale, conspicuously spotted sides as does the type of *S. alleni*. Nor have I seen such a pattern in specimens of *rubra* from other localities (Colombia, Venezuela, Upper and Lower Amazon in Brazil, Trinidad). I thus feel that Barbour and Love-

ridge v
Hyla h
materi
a valid
rubra
ogy, U

RES
NIGR
A MA
1958(f
sponse
mornin
sunshi
ditch i
of P.
proach
crouch

OCO
FISHE
AN A
collect
west o
August
fishes
of sub
collect
bottom
Flow
ond.

In t
a riffle
sized
large
eggs (
see Br
Rept.
stream
distre
specim
flabel
linae
stream
amina
wrigg
and 1
below
persis
usual
riffles

ridge were correct in assigning *Scytotis alleni* to *Hyla* but rather suspect that when, and if, fresh material becomes available, it may prove to be a valid species rather than a synonym of *Hyla rubra*.—COLEMAN J. GOIN, *Department of Biology, University of Florida, Gainesville, Florida.*

RESPONSE OF A FEMALE *PSEUDACRIS NIGRITA* *TRISERIATA* TO THE CALL OF A MALE.—As recently noted (Blair, *Copeia* 1958(4):333-4) few actual records exist of the response of female *Salientia* to the male's call. One morning in the spring of 1958, I stood in bright sunshine beside a small, shallow, clear-water ditch in central Oklahoma in which several males of *P. n. triseriata* had ceased calling at my approach. Several silent males were soon spotted crouched beneath the water on or near the bot-

tom. After a few minutes one of these swam toward me, popped his head above surface at my feet and began calling. Within two minutes, a female, unnoticed before, swam rapidly and without pause directly to this male and without touching him stopped directly before his nose with her body at approximately right angle to his. The male immediately stopped calling and clasped her.

In coming to this male, the female swam at least five feet and had passed close to several silent males. It seems clear that she responded directly to this male's call. It is also indicated that in this case physical contact was not necessary to clasping. Whether it may be so at night is problematical.—ARTHUR N. BRAGG, *Biological Survey, University of Oklahoma, Norman, Oklahoma.*

Ichthyological Notes

OCCURRENCE OF THREE SPECIES OF FISHES IN INTERSTICES OF GRAVEL IN AN AREA OF SUBSURFACE FLOW.—While collecting fishes in Hutchins' Creek, four miles west of Alto Pass, Union County, Illinois, on 23 August 1958, we observed three species of riffle-fishes inhabiting interstices of gravel in an area of subsurface percolation. At the time of our collections, the stream was very clear, gravel-bottomed, and with pools to eight feet in depth. Flow was approximately two cubic feet per second.

In the area of our observations water flowed in a riffle for about 20 feet, then beneath the egg-sized gravel for approximately 15 feet, into a large pool. At 2:30 PM we applied three cyan-eggs (96 percent Sodium Cyanide in pellet form; see Bridges, *U. S. Fish and Wildl. Serv., Spec. Sci. Rept.*—Fisheries No. 253:1-11, 1958) to the upstream end of the riffle. Within seconds fishes were distressed in the riffle, and within two minutes specimens of *Noturus exilis* Nelson, *Etheostoma flabellare lineolatum* (Agassiz), and *Cottus caroliniae* (Gill) appeared on the dry gravel, downstream from the area of surface-flow. Further examination by digging revealed these three species wriggling up through the gravel to the surface, and lying in the interstices two to three inches below the surface, where a strong flow of water persisted. *Noturus exilis* and *C. caroliniae* are usually found beneath rocks and other cover in riffles; the latter species is known to live also

in completely dark, cave habitat. *Etheostoma flabellare lineolatum* is also usually associated with riffles and is found beneath rocks.

These fishes were apparently able to move freely in the habitat described above because of the relatively large, loosely constituted gravel of the stream-bed, and the correspondingly large interstices. The water temperature two or three inches below the surface of the gravel seemed considerably cooler than at the surface of the stream. No actual temperatures were recorded.

Other fishes taken in the surface-flowing riffle (other than the three listed above) were *Campostoma anomalum* Rafinesque, *Etheostoma spectabile spectabile* (Agassiz), and *E. caeruleum* Storer. Another darter, *Percina caprodes* (Rafinesque), was observed but none was captured. More details concerning the fishes of this stream, and a description of the physical features of the area are given by Lewis and Elder (*Trans. Amer. Fish. Soc.* 82(1952):193-202, 1953). We re-identify the specimens from Hutchins' Creek recorded as *Cottus bairdi* Girard by Lewis and Elder (*op. cit.*) as *Cottus caroliniae* (Gill). Specimens collected by us are deposited at the University of Kansas Museum of Natural History.—J. L. STEGMAN, *U. S. Fish and Wildlife Service, Vicksburg, Mississippi* (formerly research assistant, *Fish Management Research Laboratory, Southern Illinois University*), AND W. L. MINCKLEY, *University of Kansas, Lawrence, Kansas* (now with *University of Louisville, Louisville, Kentucky*).

RECENT CHANGES AND CORRECTIONS FOR THE MINNESOTA FISH FAUNA.—No attempt at a complete list of Minnesota fishes has been made since the last edition of *Northern Fishes* (Eddy and Surber, *Univ. Minn. Press*, 1947). Since that time, extensive collecting over the state by the Minnesota Department of Conservation, the writers and various members of the University of Minnesota staff has yielded several species formerly reported as rare or doubtful. In addition, the failure of some provisional species to appear in recent collections seems to warrant their removal from the Minnesota list.

Several recent migrants have appeared in the Minnesota waters of Lake Superior since 1947. The appearance of the sea lamprey, *Petromyzon marinus* Linnaeus, as predicted in *Northern Fishes* has been widely publicized for the past six years. The presence of the pygmy whitefish, *Coregonus coulteri* Eigenmann and Eigenmann, in Lake Superior has long been overlooked until recently demonstrated by Eschmeyer and Bailey (*Trans. Amer. Fish. Soc.* 84:161-99, 1954). Although not yet collected from Minnesota waters, its presence in adjacent waters indicates that it should be added to the Minnesota faunal list.

A recent arrival at the western end of Lake Superior is the alewife, *Alosa pseudoharengus* (Wilson). A specimen was secured in Minnesota waters off Two Harbors from the nets of Adolf Ojard by John Hale, February 12, 1955, and deposited in the Minnesota collections. Since then several other alewives have been reported. The alewife has penetrated the upper Great Lakes in recent years and has now reached the western end of Lake Superior. A recent study of its origin and spread through the Great Lakes has been made by Miller (*Trans. Amer. Fish. Soc.* 86:97-111, 1956).

The spoonhead sculpin, *Cottus ricei* (Nelson), was reported in 1947 as present in Lake Superior but not collected in Minnesota waters. A re-examination of specimens of *Cottus* in the University of Minnesota collections indicates that this species is quite common in the Minnesota waters of Lake Superior.

The slender madtom, *Noturus exilis* Nelson, was reported for Minnesota on the identification of a single specimen from the Blue Earth River at Mankato in 1893 by Cox (*Geol. and Nat. Hist. Surv. Minn., Zool. Ser.* 3:20, 1897). This record has been doubted as no specimens have been collected in Minnesota during the following 60 years. On September 1, 1954, three specimens of the slender madtom were collected by a survey crew of the Minnesota Department of Conservation from Otter Creek, a tributary of the Red Cedar River, Mower County, three miles north

of the Iowa border. This collection definitely restores the slender madtom to the Minnesota faunal list and extends its range to southeastern Minnesota. The record of Cox for the Blue Earth River remains questionable.

The warmouth, *Chaenobryttus gulosus* (Cuvier), was included in the Minnesota list in 1947 on the basis of one specimen collected near Winona. Recent collections show that this species is not uncommon in the backwaters along the Mississippi River from Winona southward. A single specimen secured from a north-central Minnesota lake may have been introduced with sunfishes distributed in winter-kill rescue operations.

No new records for minnows and darters have been made since 1947. Additional collections have established the distributions of the following species and have been discussed recently (Underhill, *Occ. Papers Minn. Mus. Nat. Hist.* 7, 1957); northern pearl dace (*Semotilus margarita nachtriebi*), redeye dace (*Gila elongata*), pugnose minnow (*Opsopoeodus emiliae*), suckermouth minnow (*Phenacobius mirabilis*), redbfin shiner (*Notropis umbratilus*), red shiner (*N. lutrensis*), Topeka shiner (*N. topeka*), Ozark minnow (*Dionda nubila*), slenderhead darter (*Percina phoxocephala*), gilt darter (*P. evides*), banded darter (*Etheostoma zonale*), rainbow darter (*E. caeruleum*).

The fish listed as the speckled chub, *Hybopsis (Extrarius) aestivalis* (Gilbert), in 1947, and as *H. hyostomus* (Gilbert) by Cox (*op. cit.*) is not known from the state and should be removed from the Minnesota faunal list. Dr. Carl Hubbs (*pers. comm.*) has pointed out that Underhill (*op. cit.*) was in error in indicating that the above records referred to the gravel chub, *H. x. x-punctata* (Hubbs and Crowe). The gravel chub is known from the Root River, southeastern Minnesota.

The failure of many fishes listed or reported provisionally for Minnesota to appear in recent collections indicates that a number of species should be removed from the state list. The plains shiner, *Notropis percobromus* (Cope), was included in the Minnesota list on the identification by Carl L. Hubbs of several specimens mixed in two collections of *Notropis atherinoides* Rafinesque, from the Mississippi River. R. M. Bailey (*Iowa Fish and Fishing*, p. 232, 1956) on re-examination of the specimens states that these are *N. atherinoides*. This removes the plains shiner from the Minnesota fauna.

The failure of authentic records of the blue catfish *Ictalurus furcatus* (LeSueur), to appear in any of the recent collections indicates that this species may not be present and that it at least

should
madtom
peared
sota lis
of a
State C
which
identifi
blenni
in the
identifi
never
and as
of Min
from t
The
was lis
suggest
area w
the ga
Minne
It show
SAMUE
apolis,
versity
kota.

REQ
NEW
fishes
stories
trawlin
S. C.
by the
Vern
specim
were t
1958,
Botton
Briggs
lists
cies ar
from
specim
of som
activi
that c
norma
was c
shoul
mens
Museu
of Be
South
Ant
men t
Surfa
13.5°

should be placed on the provisional list. The madtom, *Noturus miurus* Jordan, has never appeared and should be removed from the Minnesota list. It was previously included on the basis of a report by Surber (*Appendix Bienn. Rept. State Game and Fish Comm. Minn.*, p. 21, 1920) which was undoubtedly based on a mistaken identification. The greenside darter, *Etheostoma blennioides* Rafinesque, was doubtfully included in the Minnesota list in 1947 because of a field identification by Surber in 1920. This species has never appeared in any of the recent collections and as its range is considerably south and east of Minnesota, it should definitely be removed from the state list.

The spotted gar, *Lepisosteus productus* Cope, was listed for southern Minnesota in 1947 at the suggestion of Carl L. Hubbs who thought this area was within its range. A close examination of the gars collected recently from many southern Minnesota Lakes has failed to reveal this species. It should be removed from the Minnesota list.—SAMUEL EDDY, *University of Minnesota, Minneapolis, Minnesota*, AND JAMES C. UNDERHILL, *University of South Dakota, Vermillion, South Dakota*.

RECORDS OF THREE MARINE FISHES NEW TO SOUTH CAROLINA.—The following fishes were taken aboard the Bears Bluff Laboratories vessel, M/V T-19, in the course of offshore trawling southeast of the North Edisto River, S. C. Collections and identifications were made by the author.

Verma kendalli Gilbert. Kendall's eel.—Three specimens (total lengths 198, 243, and 347 mm.) were taken in two drags on February 24 and 25, 1958, in the 10.5 and 13 fathom depth range. Bottom water temperatures were 9.8 and 10.2° C. Briggs (*Bull. Fla. State Mus.* 2(8):224-318, 1958) lists *V. kendalli* among the endemic Florida species and indicates the known range as extending from Miami to Key West, Florida. The present specimens represent a northward range extension of some 450 miles. The eels showed little or no activity when brought aboard, and it is possible that capture was facilitated by the effects of abnormally low temperatures. The trawl cod end was of 2-inch stretch webbing and small eels should escape with little difficulty. Two specimens have been deposited in the U. S. National Museum, and one is retained in the collections of Bears Bluff Laboratories, Wadmalaw Island, South Carolina.

Antigonia capros Lowe. Boar fish.—One specimen taken in 37 fathoms on February 25, 1958. Surface and bottom temperatures were 17.0 and 13.5° C. respectively. The following counts and

measurements (in mm.) were obtained: standard length 35; depth 45.2; length of third dorsal spine 12.2; length of pelvic spine 11.2; D. VIII-34; A. III-32; pectoral I-13. *A. capros* has been taken from Cape Hatteras, N. C., northward and from Miami, Florida, southward (*personal communication, Dr. F. H. Berry*) but this South Carolina specimen is the first record of capture between these locations. The specimen is retained in the Bears Bluff Laboratories collections.

Otophidium omostigium (Jordan and Gilbert). Spotted cusk eel.—Thirty-eight specimens were taken during a series of nine half-hour drags in 18 to 23 fathoms on the night of July 10-11, 1958. Total lengths ranged from 2.25 to 5.25 inches, and six randomly chosen specimens, retained for study, had standard lengths of 75.0, 78.1, 79.8, 80.9, 85.5 and 108.2 mm. Briggs and Caldwell (*Quart. Jour. Fla. Acad. Sci.* 18(4):289, 1955) recorded *O. omostigium*, Florida, as the northern limit of *O. omostigium*. However, Dr. C. R. Robbins states (*personal communication*) that specimens have been taken in North Carolina waters. Though generally considered rare, this species is apparently rather common in the offshore waters of South Carolina. One specimen has been deposited in the U. S. National Museum, a second in the Charleston Museum (CM 58.2.56) and the remaining four specimens are in the Bears Bluff Laboratories collections.—C. E. DAWSON, *Gulf Coast Research Laboratory, Ocean Springs, Mississippi*.

EXTREME LOSS IN BODY WEIGHT OF AN AMERICAN SHAD (*ALOSA SAPIDISSIMA*).—American shad (*Alosa sapidissima*) native to streams north of Cape Hatteras, North Carolina, do not normally die after spawning; and, if they survive natural and fishing mortality, return to their native stream to spawn in subsequent years (Talbot and Sykes, *U. S. Fish and Wildlife Service Fishery Bull.* 58(142), 1958). Since they take little or no food from the time they enter the river, spawn, and return to the sea, they must subsist on the reserve energy accumulated in the form of fat and proteins.

Each spring shad enter the Connecticut River about the first week in April, and the run continues until mid-June. A dam at Holyoke, Massachusetts, 84 miles above the mouth, prevents migrating fish from passing this point. A mechanical fish-lift installed in 1955 passes several thousand shad each spring. Shad which spawn above this dam leave the spawning grounds by mid-July. The young hatched above the dam grow to four or five inches while in the river, then in fall, migrate to sea. Both adult and young on their downstream migration bypass the dam

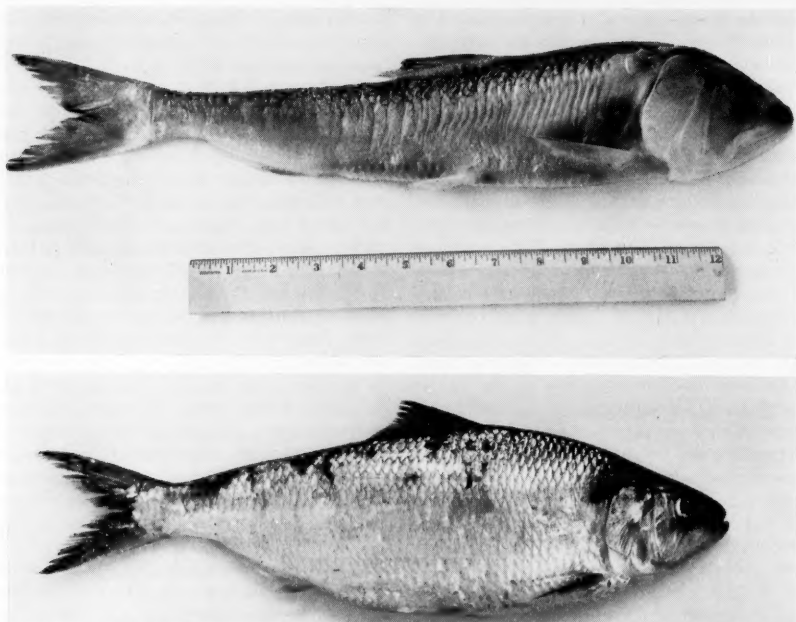


Fig. 1.—[upper] Preserved specimen of a four-year-old male American shad (*Alosa sapidissima*) from Connecticut River illustrating extreme loss in body weight after spawning and living a minimum of 120 days in fresh water; and [lower] Fresh specimen of a typical four-year-old male American shad (*Alosa sapidissima*) illustrating shad in pre-spawning condition.

through a canal system operated in conjunction with the dam.

In October, 1958, two adult shad were observed with the young in the canal system. Why or how these two adults were delayed in their downstream migration is unknown. One of these fish was captured during a mortality study conducted on downstream migrant juvenile shad. This adult fish was a four-year-old male which had spawned for the first time the previous spring (Fig. 1, upper). It weighed 1.0 pound and was 17.2 inches fork length. In contrast, the lower specimen is representative of a four-year-old male on its first spawning run. During the 1958 shad-fishing season the average weight and length of this age group in the Connecticut River was 3.2 pounds and 17.1 inches fork length, respectively.

It has been calculated that Atlantic salmon lose in body substance and in sex products discharged between 40 and 45 percent of their weight from the time they enter fresh water until they spawn. Death by starvation is known to occur in many animals when the loss in body weight exceeds 40 percent (Curtis, *Life Story of the Fish*, 1949; Krivobock, *International Council for Exploration of the Sea*, No. 63, 1958) reported that three-year-old spring-spawning salaka's (Baltic herring) total loss of fat during the maturation

of the sexual glands and the spawning amounted to 65.0 percent in 1956 and 52.4 percent in 1957.

The spawned-out adult male shad captured after spending a minimum of 120 days in fresh water had lost approximately 69 percent in body weight. Examination of the liver showed that it had atrophied to less than 20 percent normal size and was faded yellow in color. The stomach had shrunk to less than 5 percent normal size and was very hard. The gonads were very dark in color and hard-leathery in texture. Because of these morphological changes and loss in body weight, it is doubtful that this fish could have survived had it returned to the sea.—PAUL R. NICHOLS, *Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service, Beaufort, North Carolina*.

THE SNAKE-EEL, *OMOCHELYS CRUENTIFER*, IN CANADIAN ATLANTIC WATERS.—In July, 1958, a specimen of the snake-eel, *Omocheilus cruentifer* (Goode and Bean), was found attached to the stomach lining of a swordfish (*Xiphias gladius*) caught at 45° 30' N, 57° 10' W, some 100 miles off Cape Breton, Nova Scotia. It was taken by a boat captained by Fred Oates, Glace Bay, N. S., and forwarded to the Royal On-

tario Museum of Canadian History, Brunswick, N. S.

This occurrence is of interest in the Atlantic shad fishery (U. S. Fish and Wildlife Service, 1953). There is a possibility that the stomach contents of the shad could be examined for the presence of the snake-eel.

Despawning shad appear about the same as fresh shad, but the color of the skin is different.

This removal of the shad from the collection was made by the Royal Canadian Mounted Police, a unit of the Fish and Wildlife Service, results in a loss of the shad and a loss of the background color.

is unique in color and in the shape of the tail.

The diameter of the tail is three times the diameter of the body and the diameter of the tail is altered.

The Royal Canadian Mounted Police, Scott's Bay, Newfoundland, is the source of the specimen.

FEELING THE SNAKE-EEL, *OMOCHELYS CRUENTIFER*, IN CANADIAN ATLANTIC WATERS. LAKES AND RIVERS OF CANADA. *Salvelinus namaycush* (Walbaum) is the principal species of the genus *Salvelinus* in the Atlantic region. The design of the fish is of the same role as the fresh water fish.

THE

tario Museum by the Fisheries Research Board of Canada Biological Station, St. Andrews, New Brunswick. The identification was confirmed by Wm. C. Schroeder, Museum of Comparative Zoology, Cambridge, Massachusetts.

This appears to be the most northerly known occurrence and the first record in Canadian Atlantic waters. According to Bigelow and Schroeder (*U. S. Fish. Wildlife Service Fish. Bull.* 74:159, 1953) the natural range is "western side of the Gulf of Maine to the offing of Cape Henry, Va." There is, however, no way of knowing how far the swordfish travelled with the snake-eel in its stomach.

Despite its distorted condition, this specimen appears to be the largest yet recorded, measuring about 22 inches in total length. The largest recorded in Bigelow and Schroeder (*ibid.*) was 16 $\frac{3}{4}$ inches.

This specimen was hard and shrivelled when removed from the stomach and was said by the collectors to be attached to the stomach wall. It was encased in a mucosal coat when received at the Royal Ontario Museum and was at that time a uniform brownish yellow, as described in the Fishes of the Gulf of Maine. Storage in alcohol resulted in the sloughing off of this outer coating and an obvious color pattern was revealed. The background of the dorsal surface is dark, the color involved unknown, and the ventral surface is uniformly light. The pattern consists of light-colored, circular spots on the dorsal surface from immediately behind the head to the tip of the tail. These spots vary in size, being equal to the diameter of the eye at the tip of the tail, and three times that diameter at mid-body. The size and disposition of the spots present a regular and alternating, black and white, mesh-like pattern.

The specimen is housed in the collection of the Royal Ontario Museum (Cat. No. 19448).—W. B. SCOTT AND E. J. CROSSMAN, *Department of Ichthyology and Herpetology, Royal Ontario Museum, Toronto 5, Canada.*

FECUNDITY OF THE ARCTIC CHAR, *SALVELINUS ALPINUS*, OF THE WOOD RIVER LAKES, BRISTOL BAY, ALASKA.—In the Wood River Lakes region of Alaska, the Arctic char, *Salvelinus alpinus* (Linnaeus), is one of the principal predators on the juvenile sockeye salmon (*Oncorhynchus nerka*). The fishery for the adult sockeye is of great economic importance to the area. The following fecundity study was designed as a basic part of the life history study of the char and the determination of the char's role in the survival of the sockeye during their freshwater residence.

The sample of ripening female char was ob-

tained from gill-net catches from Lake Nerka of the Wood River Lakes chain in 1954. Mesh sizes of the nets ranged from one and one-half to four inches, stretched measure. Lengths, weights, stomach contents, and degree of maturity of the fish were obtained and recorded. Ovaries were removed and preserved in 10 percent formalin solution, care being exercised to preserve the identification of each ovary with respect to right or left and with the fish from which both ovaries came.

The lengths referred to are fork lengths, the distance from the tip of the snout to the fork of the tail.

The seventy-one female char examined in this study ranged in length from 375 to 545 millimeters (15.2 to 22.2 inches) and in weight from 600 to 1,850 grams (1 pound, 5 ounces to 4 pounds, 1 ounce).

To enumerate the preserved and hardened ova, the mesovarium was first removed so that each ovum was free. Two 100-ova samples from each ovary were counted, and the volume of each determined by volumetric displacement in a 25-milliliter graduated cylinder. The remainder of the ova was then placed in a 250-milliliter graduated cylinder, and the volume of the sample determined by water displacement. The total calculated number of ova in each ovary was obtained by use of a simple ratio formula.

To verify the accuracy of the method, the ova in sixteen ovaries were counted individually after the calculated number had been obtained by the sample-displacement method. The absolute mean error was determined to be 1.09 percent.

The results of the fecundity estimates are shown in Table 1. The relative fecundity values given in the table are expressed both in weight and length. Length-relative fecundity is the num-

TABLE 1
CHARACTERISTICS AND FECUNDITY ESTIMATES
OF 71 ARCTIC CHAR, *SALVELINUS*
ALPINUS, FROM WOOD RIVER
LAKES, ALASKA

Item	Mean	Range	Standard deviation
Fork length (millimeters)	438.5	375-545	35.9
Weight (grams)	986.5	600-1,850	288.9
Number of ova			
Left ovary	992.6	601-2,075	342.3
Right ovary	933.4	495-2,072	299.2
Total	1,926.0	1,182-4,038	191.7
Relative Fecundity			
Ova per centimeter of fork length	43.4	28.67-79.18	10.84
Ova per 100 grams of body weight	197.3	129.1-271.3	31.99

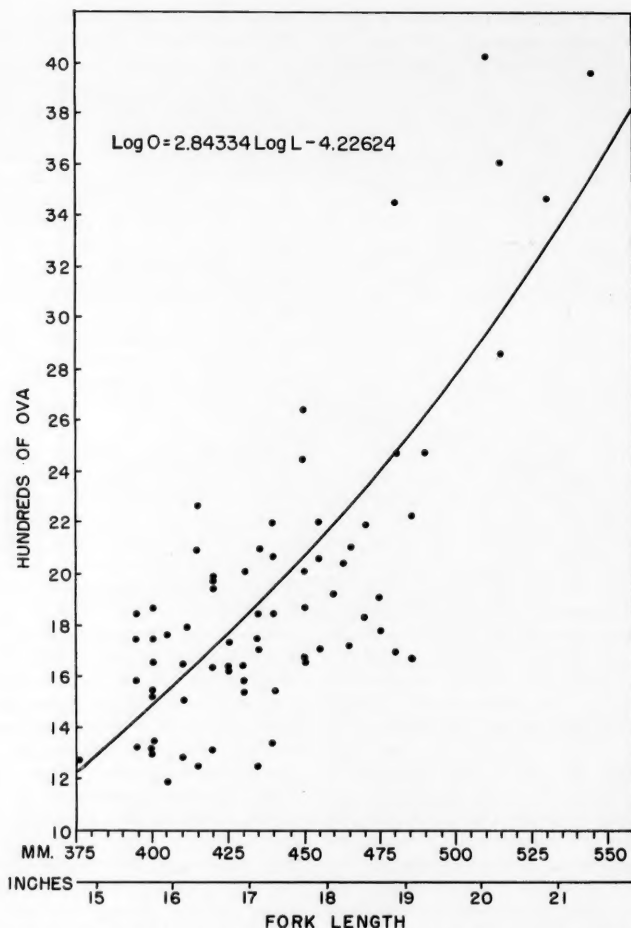


Fig. 1.—Length-fecundity relationship of a sample of seventy-one Arctic char, *Salvelinus alpinus* from Lake Nerka, Bristol Bay, Alaska.

ber of ova per centimeter of fork length; weight-relative fecundity, the number of ova per one-hundred grams of body weight.

The length-fecundity relationship of the Arctic char is shown in Figure 1. An acceptable regression line, determined by the least-squares method, was found to be expressed by the equation:

$$\text{Log } O = 2.84334 \text{ Log } L - 4.22624$$

where O is the total number of ova and L is the fork length in millimeters.

The mean egg content of the left ovary exceeded that of the right (Table 1) in 68 percent of the ovaries. When a greater number was pres-

ent in the right ovary, the difference between the two was small.

From a small sample of almost ripe females it was found that the average percentage of body weight represented by the ovaries was 24.2 ± 4.6 percent.

From this study it was determined that for comparative purposes, fecundity can best be shown by two statistics, (1) a length-fecundity regression line and (2) the relative fecundity based on number of ova per unit of fish length.—RICHARD B. THOMPSON, Bureau of Commercial Fisheries Biological Laboratory, Seattle 2, Washington.

ISTIO
PRIOR
The bla
or shiro
in the
aliases
has not
given b
Until th
(Bull. A
1955), I
tion. H
stimula
the Istio
have be
specime
lish the
basis.

Cuvie
naturel
describ
nished
pound
viously
could l
cific bl
used h
entities
those o
fact th
plete,
that th
include
of the

Rece
tional
plied
duced
charac
are tal
each
Study
Monte

At
of the
black
lapped
species
depth
higher
and fa
species
allome
only h
ample
the de
body

ISTIOMPA *INDICUS* (CUVIER) 1831, A
PRIOR NAME FOR THE BLACK MARLIN.—

The black marlin of English-speaking fishermen, or shirokawa or shirokajiki of the Japanese, has in the past gone under a number of scientific aliases, resulting in a confusion of names that has not been relieved by the poor descriptions given by so many of the earlier ichthyologists. Until the publication of LaMonte's monograph (*Bull. Amer. Mus. Nat. Hist.* 107(3):323-358, 1955), little had been done to clarify the situation. Her work, however, provided considerable stimulation to research into the classification of the Istiophoridae. As a result, considerable efforts have been made to re-discover and examine type specimens and other material in order to establish the nomenclature of the family on a stable basis.

Cuvier (in Cuvier and Valenciennes, *Histoire naturelle des poissons*, vol. 8, pp. 286-287, 1831) described *Tetrapturus indicus* from a sketch furnished by Sir Joseph Banks of a nine-foot, 200-pound fish from Sumatra. The description is obviously of a marlin, and on geographical grounds could be the striped, the black, or the Indo-Pacific blue marlin. (English common names are used here, since their relationships to species entities are much better-established than are those of the various scientific names.) Despite the fact that Cuvier's description is rather incomplete, LaMonte (*op. cit.*:338) was able to deduce that the fish was probably a black marlin, and included the name with a query in her synonymy of the species.

Recently, the librarian of the Museum National d'Histoire Naturelle, Paris, kindly supplied a photocopy of Banks' drawing, reproduced here as Fig. 1. The various important characters that can be determined from the sketch are tabulated, along with comparative data for each of the three possible species, in Table 1. Study of this table leaves no doubt that LaMonte's deduction was correct.

At 11.9 percent of the fork length, the height of the dorsal fin of *T. indicus* is typical of the black marlin, even though this value is overlapped by the low extremes of both of the other species. Expressed as a percentage of the body depth, the dorsal height (73.7 percent) is in the higher part of the range for the black marlin, and falls outside the low extremes of the other species. It is important, because of pronounced allometry in this ratio, that comparisons be made only between fish of about the same size. For example, in small black marlin under 60 pounds, the dorsal may be as high as 96 percent of the body depth, and in very large blues it may be

as low as 66 percent. The comparison has therefore been limited as noted.

The height of the anal fin of *T. indicus* is 13.9 percent of the body length (fork length without head). This value falls below the mean of the black marlin for this character, and is well below the extreme low values for either of the other species. As compared with the height of the dorsal, the anal height is typical for the black marlin, but is overlapped by the ranges of both the blue and the striped for this ratio. The number of dorsal rays (assumed 39 or 40) is inconclusive; this character exhibits so much variation that it is of little diagnostic value. The number of anal rays, however, again points to the black and excludes the blue marlin.

Royce (*U. S. Fish Wildl. Ser. Fish Bull. No. 124, 57:504, 511-512, 1957*) found that the ventral fins of marlins exhibit almost no change in length with size of the fish, hence average fin lengths could be compared directly. For *T. indicus*, the length of the ventral fins, computed from the stated total length of nine feet, again places the species with the black marlin. However, it is necessary to assume that the fins were unbroken, which lowers the degree of reliance that may be placed on this character here.

The last character, the rigidity or non-rigidity of the pectoral fin, again requires the assumption that the artist drew the fin in the extended position because it could not be adducted flat to the body. In all known marlins except the black marlin, this fin can be folded flat against the body, and is almost always found in this position in a dead fish. On the other hand, the pectoral fin of the black marlin cannot be folded flat against the body at all. This was pointed out by Gregory and Conrad (*Bull. Amer. Mus. Nat. Hist.* 76(8):453-454, 1939), treated with some doubt by LaMonte (*op. cit.*:337), pointed up firmly as a "most distinctive character" by Royce (*op. cit.*:524), and seized upon enthusiastically by Morrow (*Bull. Bingham Oceanogr. Coll.* 16(2): 88-105, 1958). Banks' artist, who presumably drew the sketch on which *T. indicus* was based, was a competent and experienced zoological illustrator. One cannot conceive that he would have drawn the fin extended unless it actually could not be folded. If this is so, then it is another point indicating the black marlin.

In summary, then, the following characteristics of *T. indicus* fall outside the range of variation for, and eliminate identification with, the striped marlin: (1) height of dorsal as percent of depth; (2) height of anal as percent of fork length without head; (3) length of ventral fins; (4) presumed rigidity of pectoral fins. The following characters fall outside the range of variation for,

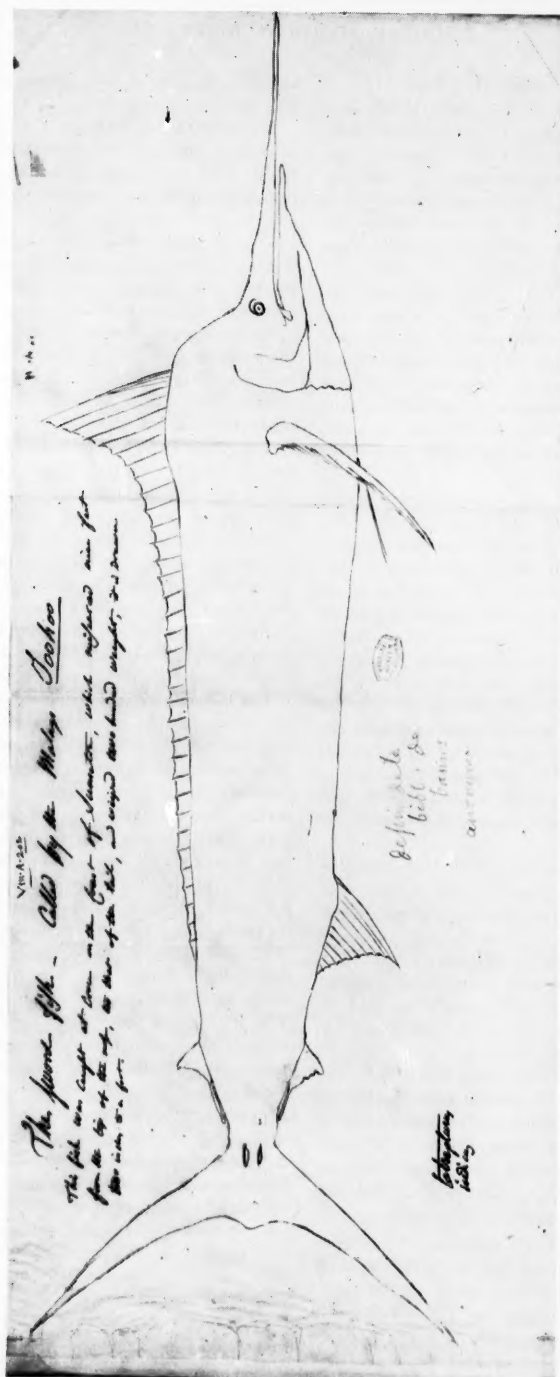


Fig. 1.—Sketch sent by Sir Joseph Banks to M. Broussonet, and used by Cuvier as the type of *Tetrapturus indicus*. The note reads: "The sword fish—called by the Malays Jookoo. This fish was caught at Croce (?) on the coast of Sumatra, which measured nine feet from the tip of the nose, to that of the tail, and weighed two hundred weight, it is drawn two inches to a foot."

Cr

Chara

¹ Height
as %

² Height
as %

Height a
% F

head
%

¹ Height a
%

dorsal
No.

rays
No. anal

Length
fins, (

Pectora
adduc

¹ Com

Fish Wild
proportion

blue, and

² Becu

size—16

² Esti

shown in

and pro

blue m

depth;

without

of vent

fins. Th

percent

percent

within

striped

values

that sp

numbe

eight c

nate th

marlin

rather

clusive

istics i

that T

and th

In c

sider t

genus,

dicus

cies. o

type sp

TABLE 1
CHARACTERISTICS OF VARIOUS SPECIES
OF INDO-PACIFIC MARLINS

Character	<i>T. indicus</i>	Black marlin	Blue marlin	Striped marlin
¹ Height dorsal as % FL	11.9	(10.2-13.4)	(11.1-16.1)	(11.6-19.8)
² Height dorsal as % depth	73.7	(53.9-77.2)	(75.2-91.2)	(102.3-156.1)
Height anal as % FL w/o head	13.9	(11.9-15.7)	(15.5-19.9)	(16.2-20.8)
¹ Height anal as % height dorsal	80.1	(68.1-100.4)	(76.4-100.2)	(50.2-81.1)
No. dorsal rays	36 ³	(35-42)	(38-46)	(37-44)
No. anal rays	13	(11-14)	(14-17)	(13-17)
Length ventral fins, (cm.)	22.6	(20.4-32.1)	(24.5-42.1)	(27.4-57.4)
Pectoral fin adducted	No	No	Yes	Yes

¹ Comparative data on these two items from Royce (*U. S. Fish Wildl. Serv. Fish. Bull. No. 124* 57:496-554, 1957). All other proportions and counts based on our own data on 69 black, 80 blue, and 92 striped marlin from Pacific and Indian oceans.

² Because of allometry, based only on fish of comparable size—16 black and 12 blue, 150-250 lbs.; 31 striped, 103-212 lbs.

³ Estimate 3 or 4 more rays hidden by fin sheath, hence not shown in drawing.

and prevent identification with, the Indo-Pacific blue marlin: (1) height of dorsal as percent of depth; (2) height of anal as percent of fork length without head; (3) number of anal rays; (4) length of ventral fins; (5) presumed rigidity of pectoral fins. The two characters, height of dorsal fin as percent of fork length, and height of anal fin as percent of height of dorsal, although included within the ranges of both the blue and the striped marlin, fall almost precisely on the mean values for the black marlin, and therefore suggest that species rather than either of the others. The number of dorsal rays is inconclusive. Of the eight characteristics examined, then, four eliminate the striped marlin, five eliminate the blue marlin, two suggest strongly the black marlin rather than the other species, and one is inconclusive. But every single one of these characteristics is completely compatible with the thesis that *T. indicus* and the black marlin are one and the same species.

In conformity with modern ideas, which consider the black marlin to represent a separate genus, the name of the species is *Istiompax indicus* (Cuvier) 1831. It is the type and only species of the genus *Istiompax* Whitley 1931. The type specimen itself was not preserved. The type

material is a pen and ink drawing of a specimen nine feet in total length and weighing two hundred pounds, from Sumatra. The drawing is with the original manuscript of the *Histoire naturelle des poissons* by Cuvier and Valenciennes, in the library of the museum National d'Histoire Naturelle, Paris.

SYNONYMS AND REFERENCES

- Tetrapturus indicus* Cuvier 1831, *In* Cuvier and Valenciennes, *Histoire naturelle des poissons*, vol. 8, pp. 286-287, Paris.
- Tetrapturus australis* Macleay 1854, *Illus. Sydney News* 1(23):179.
- Histiophorus brevirostris* Playfair 1866, *In* Playfair and Günther, *The fishes of Zanzibar*, pp. 53 and 145, London.
- Histiophorus gladius non* Bloch 1793, *sed* Ramsay 1881, *Proc. Linn. Soc. N. S. W.* 5:295-297.
- Makaira marlina* Jordan and Hill 1926, *In* Jordan and Evermann, *Occ. Pap. Calif. Acad. Sci.* 12:59-60, pl. 17.
- Istiompax australis* Whitley 1931, *Rec. Aust. Mus.* 18(4):147-150.
- Makaira indicus* (Partim) Deraniyagala 1933, *Spolia Zeylan.* 18:55-56.
- Makaira nigricans tahitiensis* Nichols and LaMonte 1935, *Amer. Mus. Novit.* 807:1-2.
- Makaira nigricans marlina* Nichols and LaMonte 1935, *Nat. Hist., N. Y.* 36(4):328.
- Makaira ampla marlina* Nichols and LaMonte 1941, *Ichth. Contrib. Internat. Game Fish Assoc.* 1(1):8, fig. 1.
- Makaira ampla tahitiensis* Nichols and LaMonte 1941, *Ichth. Contrib. Internat. Game Fish Assoc.* 1(1):8, fig. 3.
- Martina marlina* Hirasaka and Nakamura 1947, *Bull. Oceanogr. Inst. Taiwan* 3:15, pl. 3, fig. 1.
- Istiompax dombraini* Whitley 1954, *Aust. Zool.* 12(1):60.
- Makaira mazara* (partim) non Jordan and Snyder 1901, *sed* LaMonte 1955, *Bull. Amer. Mus. Nat. Hist.* 107(3):336.
- Makaira mazara tahitiensis* LaMonte 1955, *Bull. Amer. Mus. Nat. Hist.* 107(3):342.
- Makaira marlina marlina* Morrow 1958, *Bull. Bingham Oceanogr. Coll.* 16(2):88-105.
- Makaira marlina tahitiensis* Morrow 1958, *Bull. Bingham Oceanogr. Coll.* 16(2):88-105.
- Non Makaira indicus* Deraniyagala 1933, *Spolia Zeylan.* 18: pl. III, figs. 1 and 2.
- Grateful acknowledgment for assistance in and support of the necessary field work is made to Wendell W. Anderson, Thomas Shevlin, Alfred C. Glassell, Jr., and John K. Howard.—JAMES E. MORROW, JR. Bingham Oceanographic Laboratory, Yale University, New Haven, Connecticut.

REVIEWS AND COMMENTS

NATURAL SELECTION AND HEREDITY. By P. M. Sheppard. Philosophical Library (New York), 1959: 212 pp. \$6.00.—Sheppard's book presents a concise, but useful summary of some ideas relating to the genetical basis of the theory of natural selection. While it is simpler than Fisher's *The Genetical Theory of Natural Selection* (1930, Dover reprint 1958), it still requires some background and considerable attention of its reader. The volume would seem to be particularly suitable as supplementary reading for undergraduate biology majors, and as a review and exposition for those interested in the author's special topics.

The volume starts with a historical introduction to natural selection, plus two chapters on genetical principles. In the following chapters, which deal with the topics of "Polymorphism," "Stable polymorphism," "Polygenic inheritance and selection," "Recombination, mutation and genetic drift," "The evolution of dominance," "Protective coloration," "Mimicry," and "Ecological genetics", there is conscious emphasis on the more detailed treatment of specific examples, often of cases on which Sheppard has worked, and these sections are clearly the best part of the book. The last two chapters on "The origin of species" and "Conclusions on evolution and selection" do not maintain this level. The final section gives the impression of an after-thought.

For each principle there is a brief theoretical treatment followed by the analysis of specific examples. Sheppard has made extensive use of Lepidoptera both as experimental subjects and as illustrative examples for the present volume. In spite of this fact the book is of general interest. It furthermore points out some aspects, such as the evolutionary implications of polymorphism, useful for continued investigation in the lower vertebrates. The treatment of open problems and presentation of recent work may include some controversial concepts, but it manages to emphasize that the field is one in which active investigation is taking place.—CARL GANS, *Department of Biology, The University of Buffalo, Buffalo 14, New York.*

COMPARATIVE ENDOCRINOLOGY. Edited by Aubrey Gorbman. John Wiley & Co., New York, 1959: 746 pp. \$15.00.—Forty-two contributions by a formidable band of specialists on widely varying aspects of endocrinology. This is

a report of the second international symposium sponsored by Columbia University and held at Cold Spring Harbor and as such has the usual defect of symposia that the coverage of the subject listed in the title is very incomplete and erratic, reflecting rather narrowly the research interests of the participants. Even among symposia it is remarkable in having no unifying themes. As the talk of specialist to specialist it is not for the general reader.

On the other hand, as a mine of extremely up-to-date information on many a fascinating subject, it must be highly recommended. The range is from the morphological to the chemical. *Copeia* readers will find especially interesting the discussions of endocrines and ecological adaptations (especially temperature and salinity adaptations) in fishes (Hoar), factors in the migration of fish (Baggerman), hormones and reproductive behavior (Aronson), amphibian ovulation (Witschi), phylogeny of neuroendocrine interrelations (Scharer), thyroid problems (Gorbman), heterotopic thyroid tissue in fishes (Baker-Cohen), iodine metabolism (Berg, Gorbman, and Kobayashi), thyroid function in development (Kollros), comparative anatomy of the hypophysis (Green and Maxell, Wingstrand), pituitary hormones in fishes (Pickford), amphibian reproductive adaptations (Gallien), spermatogenesis in *Rana* (G. J. Van Oordt, *et al.*), reptilian reproductive adaptations (Miller), adrenal cortex (I. C. Jones, *et al.*), pancreas physiology (Houssay, Miller, and Wurster), urophypophysis of fishes (Enami), corpuscles of Stannius (Ford). As this bare listing shows, anyone with more than a casual interest in the topic can ill afford to pass this volume by. There is an index of animal names and a subject index.

LA VIE DES AMPHIBIENS ET REPTILES. By Robert Mertens. Horizons de France, Paris, 1959: 207 pp., 16 colored plates, 80 black and white photographs.—This superlative volume is another of the series that has included the volumes on *The Tropics* by De La Rue, Bourbiere, and Harroy; on *Fish* by Le Danois, Millot, Monod, and Budker. Like them the plates in this work have been selected with exemplary care both for their beauty and for the information they convey. Arranged in taxonomic sequence they include figures of some very rare or poorly known animals, e.g. *Mertensiella luschni* among

salamanders, amphibians, and reptiles. The illustrations are of the highest quality.

The book is a senior high school man who writes ever has name sh plan of inely al arrange ductory logeny. tion rel burrow adaptat ter, etc social growth, must b are tak generic tell so There. one ho

ZOO by Carl Advanc 1958: 5 \$10.50. to rev treatm 17, 195 view b recom tion in the "C water on the organi plemen ton. A sense the au tures cussion who a subject indepe lingto sions those ton's,

salamanders and *Diplometopon zarudnyi* among amphisbaenids as well as some very striking figures of parallelism in structure and color pattern. A few errors in the labelling of the plates are partly corrected by an errata slip.

The text is by Robert Mertens, certainly the senior herpetologist now living and certainly the man who has seen more of the creatures he is writing about alive in the wild than anyone else ever has. No further recommendation than his name should be needed, but a word about the plan of the text will not be amiss. It is genuinely about the biology of the animals so its arrangement is not taxonomic, though an introductory chapter discusses classification and phylogeny. Successive chapters deal with distribution relation with the environment (terrestrial, burrowing, arboreal, and aquatic adaptations, adaptations in relation to temperature and water, etc.), feeding, protection against enemies, social behavior, reproduction, development, growth, and length of life. One criticism only must be made: of the 207 pages more than half are taken up by the plates, preface, index to generic names, etc. What is left is too little to tell so large a story; the book is all too short. There is to be an English edition of this work; one hopes for an enlarged version also.

ZOOGEOGRAPHY. Publication No. 51. Edited by Carl Hubbs. American Association for the Advancement of Science, Washington, D. C. 1958: 509 pp. \$12.00; prepaid to AAAS members \$10.50.—It is almost presumptuous and redundant to review a book which has already received treatment by P. J. Darlington in *Science* (April 17, 1959) and in addition contains a kind of review by its editor. However, the volume deserves recommendation to *Copeia* readers. A presentation in a single volume of two symposia—one on the "Origins and affinities of the land and freshwater fauna of western North America" and one on the "Geographic distribution of contemporary organisms." It is an excellent supplement or complement to the already classic book by Darlington. As Darlington himself has noted, it is in no sense a substitute for his book, and certain of the authors disagree with him. Both these features contribute to the book's utility. As a discussion of relatively narrow topics by persons who are intimately acquainted with details of the subjects about which they write and who have independently and without the benefit of Darlington's over-all distance view come to conclusions that can be compared and contrasted with those of their co-contributors and with Darlington's, this book is admirable precisely because it

presents data on which the larger distant view can be in part reassessed. Each reader must be invited to make his own reassessment.

The papers by King and by MacGinitie on evolution respectively of surface features and of climate in western North America set an admirable background for the major part of the volume. The skeptical report by Bartholomew on the role of physiology in distribution is a good corrective to careless statements on this topic. D. E. Savage dealing with fossil mammals and Burt with Recent mammals are both critical of the Darlingtonian hypothesis of tropics and temperature as of primary importance for this vertebrate class. R. R. Miller dealing with freshwater fish agrees remarkably closely in his estimation of the affinities of North American fish with Burt's estimation of the affinities of North American mammals (55 percent Eurasian, 15 percent South American in fish, 57 percent Asian, 13 percent South American in mammals). A very interesting special case in amphibian and reptile distribution—the Coast Range corridor in California—is discussed by Peabody and Savage on the basis of a combination of geological and biotic data. Blair and Martin independently stress Pleistocene climates in relation to distribution; Martin additionally emphasizes the role of primitive man in Pleistocene extinctions. There are many provocative points made and cross references to be found in this assemblage of papers. A wide variety of evidences and techniques of analysis are employed. In so generally laudable a series, it is particularly a matter of regret that Stebbins' paper on the amphibians and reptiles should appear only as an abstract.

ZOOGEOGRAPHY OF THE SWEDISH AMPHIBIANS AND REPTILES WITH NOTES ON THEIR GROWTH AND ECOLOGY. By Torsten Gislén and Hans Kauri. Acta Vertebratica (Stockholm), 1(3):197–397, 69 figs. incl. maps, 25 tables. 1959: 40 Swedish Kronor (\$6.00).—This issue, the third number of a new serial, forms an interesting and useful addition to the various regional treatments of European herpetology. The study was completed by Kauri, who added a section (on neoteny in *Triturus vulgaris* + a new ssp.) and edited the almost finished manuscript after Gislén's death.

There is a detailed analysis of past and present distributions of the seventeen species of the Swedish herpetofauna with dot maps and detailed distribution records given for all species. Some forms are illustrated and there are discussions of ontogenetic, sexual, and regional variation of color pattern and body proportions. Mis-

cellaneous data on feeding habits, breeding, and ecology are also included. The brief terminal section sums up the over-all zoogeographic trends and presents the only excuse for calling this paper a zoogeography. The authors conclude that there has been a continuing southward shift of faunal limits during historic time and discuss human and climatic factors possibly responsible for this.

The main advantage of the book to the American reader is that it summarizes an enormous amount of original Scandinavian literature. There are references to and discussions of such topics as the applicability of Allen's rule to salamanders and the salt water tolerance of amphibians. However, the lack of an index (presumably to be furnished for the serial as a whole) is an unfortunate handicap.

It is difficult to find fault with this extensive a study, but one cannot help but regret that the Norwegian fauna was not included. The Scandinavian peninsula forms a biogeographic unit and its treatment as a whole rather than by political regions would have been both logical and useful. In spite of such philosophical quibbles, the volume deserves the attention of students of the temperate herpetofauna.—CARL GANS, *Department of Biology, The University of Buffalo, Buffalo 14, New York.*

QUER DURCH AUSTRALIEN (Across Australia). Biologische Aufzeichnungen über eine Forschungsreise. By Robert Mertens. Waldemar Kramer Verlag, Frankfurt a. M., Senckenberg-Buch 36, (10 x 16 cm.), 1958: 200 pp., 8 col. pls., 39 figs., 1 map.—Mertens' travelogues need little introduction to American herpetologists. Most of us are familiar with the continuing series of excellently illustrated popular reports in *Natur und Volk*, which form a useful supplement to the more technical faunal and taxonomic studies.

The present book deals with the 1957 Senckenberg expedition to Australia, and something less than half of the small volume forms an expanded reprint of previous articles. There are the customary regional and personal descriptions, interspersed in characteristic fashion with comments on distribution, structure, and behavior of the species (Latin name always given in parentheses) encountered and collected. The author's obvious enthusiasm makes for remarkably easy reading, yet it should be noted that occasional asides comment on a variety of biological problems. Thus the negative remarks on recent work on the genus *Crinia* (p. 50) and the argument for a Cretaceous land bridge between South America and Australia (p. 197).—CARL GANS, *Department of Biology, The University of Buffalo, Buffalo 14, New York.*

EDITORIAL NOTES AND NEWS

MYRON GORDON

1899-1959

Myron Gordon is best known for his work on the inheritance of melanoma in hybrid fishes. This pigment-cell cancer is uncommon but especially malignant in man; it occurs in many other animals but can be produced at the will of the experimenter only by crossing certain fishes belonging to the genus *Xiphophorus*. Although his work had pertinence to medical science, Dr. Gordon always looked at it from the zoologist's point of view, for his early training was not as an oncologist, but as an ichthyologist and geneticist. He focused most of his attention and almost all of his research effort on a single genus of small, freshwater fishes whose adaptability to laboratory life, pigmentary polymorphism and ability to produce fertile interspecific hybrids make them uniquely useful experimental

animals. Dr. Gordon was convinced that the broad, biological approach to the cancer problem must not be neglected; this led him to study many aspects of the biology of *Xiphophorus*. He published 72 papers on the members of this genus, as well as many abstracts and popular articles and a number of summaries of his work.

In the course of his most important investigations, Dr. Gordon (1) conclusively demonstrated the heritable nature of melanoma in *Xiphophorus* and the essential relationship of the macromelanophore to its development, (2) clarified the hereditary basis for sex determination and discovered that in some populations of *X. maculatus* the males are heterogametic, while in others the females are—a situation unique among vertebrates, (3) analyzed polymorphism in *Xiphophorus* and applied the results toward a better understanding of intraspecific variability and speciation, (4) proposed complementary onto-

genetic
origin
Xiphophorus
determin
(6) em
the va
by dev
the on
thermo
ganize
ment-
resulti
Dr.



Myron Gordon, June, 1953

genetic and phylogenetic theories to explain the origin of melanoma, (5) studied hybridization in *Xiphophorus* and its effects on pigmentation, sex determination, skeletal morphology, and sterility, (6) emphasized and, by example, demonstrated the value of fishes as laboratory animals, in part by developing special genetic strains, among them the only closely and systematically inbred poikilothermous vertebrates in the world, and (7) organized four international conferences on pigment-cell biology and edited the three volumes resulting from these meetings.

Dr. Gordon also collaborated in studies on

transplantation, tissue culture and micrurgy, ecology, cytology, endocrinology, behavior, comparative oncology, population genetics, and systematics. At the time of his death, the principal subjects on which he was working were the life histories of the normal and the cancerous melanocyte, the inheritance of susceptibility to thyroid tumors in various laboratory strains of poeciliid fishes, and the inheritance of sex in different geographic populations of *Xiphophorus maculatus* and their hybrids.

Born in Odessa, Russia, on December 11, 1899, Myron Gordon came to the United States with

his family at the age of five and was naturalized in 1912. Although he was brought up in Harlem, in the heart of populous Manhattan, his interest in animals and plants soon manifested itself, and by the time he had matriculated at Cornell University he had kept innumerable fishes as pets and had worked in the Bird House at the New York Zoological Park (Bronx Zoo) and on a farm raising game birds. He received a B.S. degree in 1925 and a Ph.D. in zoology four years later. In 1924, he had organized a fish genetics laboratory at Cornell under the joint sponsorship of three departments, Plant Breeding, Aquiculture and Zoology, and his thesis concerned the morphology of heritable color patterns in *Xiphophorus maculatus*, one of the species he maintained there. In 1937, Dr. Gordon left Cornell and for approximately one year he continued his research under the auspices of the Yale School of Medicine. From 1938 through 1940, he was a Guggenheim Fellow, during which time he made a collecting trip to Mexico to obtain the fishes that formed the foundation stock for a genetics laboratory he then established at the New York Aquarium under the aegis of its parent organization, the New York Zoological Society. Dr. Gordon became Research Associate in Genetics at the Aquarium in 1941, served as Assistant Curator from 1944 to 1947 and that year was appointed Geneticist, the position he held until his death.

When the original building of the New York Aquarium, which was located at the Battery, was closed down in the fall of 1941, the Genetics Laboratory was moved uptown to the American Museum of Natural History, where the Department of Birds generously provided space and facilities. Major financial support for the Laboratory was provided by the National Cancer Institute; for 13 years Dr. Gordon was Principal Investigator of a project dealing with "Genetic and Correlated Studies of Normal and Atypical Pigment Cell Growth." He was a Research Associate in the Department of Animal Behavior at the American Museum and an Adjunct Professor in the Graduate School of Arts and Sciences of New York University in which he taught a course in Fish Genetics. He considered his relationship to students, including those in high school, to be a matter of great importance. From 1930 to 1957, he made nine trips to Mexico and Central America, principally to collect *Xiphophorus* for population analyses and breeding experiments.

Dr. Gordon's first scientific paper, which was written with G. C. Embury and appeared in 1924, was "A Comparative Study of Natural and Artificial Foods of Brook Trout;" his last was "The Melanoma Cell as an Incompletely Differentiated Pigment Cell." It was published a few

weeks after his sudden, unexpected death from heart failure on March 12, 1959.—JAMES W. ATZ AND DONN E. ROSEN, *Genetics Laboratory, New York Aquarium, New York Zoological Society, New York, New York.*

News Notes

DR. DAVID K. CALDWELL, United States Fish and Wildlife Service, Brunswick, Georgia, has begun a study of the ecology and systematics of the shorefishes of Jamaica—conducted under the auspices of the American Philosophical Society, the Florida State Museum, and the Institute of Jamaica. He would appreciate hearing from curators of fish collections having Jamaican fishes.

JOSÉ ALVAREZ DEL VILLAR, Mexican biologist for many years connected with the federal Game and Fish Department, was appointed Subdirector de la Escuela Nacional de Ciencias Biológicas in Mexico City, on August 25.

DR. MAX HENSLEY, Michigan State University, East Lansing, Michigan, is continuing to collect materials pertaining to albinism and contemplates preparing supplements to his recent survey "Albinism in North American Amphibians and Reptiles" as new records accumulate. He would be interested in learning of published records overlooked by him in his recent summary and of any recently acquired, living or preserved, albinistic specimens. He has been urged by friends to act as recipient for records of albinism in order to reduce the number of scattered notes in many journals and to collect and record cases of albinism that are encountered by investigators who, feeling that isolated instances are not of sufficient significance to be published, never make them available. Full credit will be given each contributor.

DR. RICHARD J. BALDAUF passes on to ASIH members who may be interested that DR. WILLIAM HOSMER, 2 Alice Street, Atherton, North Queensland, Australia, has expressed interest in exchanging stereo slides of Australian amphibians and reptiles for stereo slides of American species.

A and M College of Texas

Two undergraduates in the Department of Wildlife Management have recently been awarded grants from the Texas Academy of Science to conduct the following short-term research projects under the direction of DR. RICHARD J. BALDAUF: MR. CHARLES W. RAMSAY, A Comparative Study of the Pectoral Girdle of the Hyliidae of Texas; and MR. FRED A. MURRAY, A Study of the Efferent Branchial Arteries and their Association with the Dorsal Aorta in Selected Centrarchids.

The following graduate students are conduct-

ing stu
the dir
BIGGS,
dactyl
parativ

JAME
zoogeog
member
his doc

Nat Fou

Science
closing
posals
Propos
viewed
tion's
made a
closing
15, 196
the su
quiries
ence F

graphs
entitle
Structu
Fishes.
246, th
"Misc
cated
tween
feedin
will be
correct
could
tribut
ordina
of pro

TH
A
petolo
State

ing studies on the subjects indicated, also under the direction of DR. BALDAUF: MR. WALTER C. BIGGS, Comparative Osteology of the Leptodactylidae; and MR. WALTER W. ROBERTSON, Comparative Osteology of Selected Clupeids.

JAMES R. DIXON is studying the systematics, zoogeography, and ecology of the New World members of the lizard genus *Phyllodactylus* for his doctoral dissertation.

National Science Foundation

The Division of Biological and Medical Sciences of the National Science Foundation announces that the next closing date for receipt of basic research proposals in the Life Sciences is January 15, 1960. Proposals received prior to that date will be reviewed at the spring meetings of the Foundation's advisory panels and disposition will be made approximately four months following the closing date. Proposals received after the January 15, 1960, closing date will be reviewed following the summer closing date of May 15, 1960. Inquiries should be addressed to the *National Science Foundation, Washington 25, D. C.*

Correction

In *Copeia* 1959 (3), an unfortunate and unavoidable transposition of paragraphs occurred in DONALD W. STRASBURG's article entitled "Notes on the Diet and Correlating Structures of Some Central Pacific Echineid Fishes." In the lower left-hand column of page 246, the paragraph beginning with the heading "Miscellaneous adaptations.—..." should be located in the left-hand column of page 247 between the paragraph ending with "...parasite-feeding species." and the one beginning with "It will be noted from..." The lapsus was detected, corrected, and mailed by DR. STRASBURG, but it could not be rectified before the issue was distributed because of some inexplicable and inordinate delay in delivery of this particular set of proof to the editor's desk.

New Publications

DR. THANE S. ROBINSON, Director of the Charles C. Adams Center for Ecological Studies, calls attention to their new series entitled *Occasional Papers of the C. C. Adams Center for Ecological Studies*. The first number will appear in late 1959 or early 1960. Persons or organizations interested in being placed on the Center's mailing list should contact: Director, C. C. Adams Center for Ecological Studies, Western Michigan University, Kalamazoo, Michigan.

DR. DAVID K. CALDWELL invites particular attention to a new reprint of the invaluable and long-unavailable study by WILLIAM K. GREGORY entitled "Fish Skulls: A Study of the Evolution and Natural Mechanisms" published originally in 1933 in the *Transactions of the American Philosophical Society*. ERIC LUNDBERG, Laurel, Florida, is providing a fine offset edition, well-bound and on excellent paper, for \$15.00.

Notice of Chicago Meeting

The next annual meeting of ASIH will be held in Chicago, June 17-19, 1960. The Board of Governors will meet the evening of June 16. Chicago Natural History Museum will be the host institution. The local committee recommends the Conrad Hilton Hotel, Michigan Boulevard, Chicago 5, as being the most conveniently located and urges members to make reservations there as soon as possible. Information on room rates will be sent to members shortly.

All titles of papers should be addressed to: DR. GEORGE RABB, *Chicago Zoological Society, Brookfield, Illinois*. All titles and information concerning time and optical equipment required must be in DR. RABB's hands by May 1, 1960. Questions about other matters should be addressed to: DR. ROBERT F. INGER, *Chicago Natural History Museum, Chicago 5, Illinois*.

SUMMARY OF 1959 MEETING

THE thirty-ninth annual meeting of the American Society of Ichthyologists and Herpetologists was held on the campus of San Diego State College, San Diego, California, from June

17 to 21, inclusive. The sessions were held in conjunction with the Western Division of the American Association for the Advancement of Science and several affiliated Societies. The Herpetology

gists' League met in conjunction with each of the herpetological sessions. The Local Committee consisted of DAVID L. JAMESON, Chairman, and ELBERT H. AHLSTROM, WILBERT M. CHAPMAN, RONALD W. CRAWFORD, ALFRED W. EBELING, ARTHUR O. FLECHSIG, SAM D. HINTON, CARL L. HUBBS, L. M. KLAUBER, SALLY KRAUSE, RICHARD J. KREJSA, GEORGE LINDSAY, KENNETH S. NORRIS, GRACE L. ORTON, JAY C. QUAST, RICHARD ROSENBLATT, BETTY SHOR, FREDERICK H. STOYE, and MERREL A. TAYLOR.

EVENTS OF TUESDAY, JUNE 16

Many members arrived at San Diego a day in advance of the ASIH meetings in order to attend the first sessions of the symposium on "The Biogeography of Baja California and Adjacent Seas" sponsored by the Society of Systematic Zoology and held under the chairmanship of Dr. ENRIQUE BELTRAN of the Instituto Mexicano de Recursos Naturales Renovables. During the early evening many of the delegates and their wives attended a barbecue at the San Diego Zoo as guests of the Zoological Society of San Diego.

EVENTS OF WEDNESDAY, JUNE 17

The first meeting of the Society was called to order by PRESIDENT REEVE M. BAILEY. The Society was welcomed to the campus of San Diego State College by DR. ERNEST B. O'BYRNE, Vice-President of that institution. After a suitable response, PRESIDENT BAILEY first mentioned the recent death of JOHN TREADWELL NICHOLS, founder of *Copeia*, and then spoke briefly upon the present status of ASIH, commenting upon its size, growth, and current problems. A total of 123 persons attended this opening meeting. (Some twenty-five or thirty additional members yielded to a counter attraction and were discovered somewhat later attending the closing session of the symposium on Baja California.) The following papers were presented:

Origin of Hybrid Swarms in the Mexican Viviparous Fish Genus *Poeciliopsis*. Robert R. Miller, University of Michigan, Ann Arbor.

Effects of Venoms on Neuromuscular Transmission. Findley E. Russell and Truman E. Long, College of Medical Evangelists, Los Angeles.

Instrumental Conditioning of Sharks. Eugenie Clark, Cape Haze Marine Laboratory, Placida, Florida.

Behavioral Aspects of Anesthesia in Fishes. William N. McFarland, University of Texas, Port Aransas.

Temperature Selection in the Opaleye, *Girella nigricans*. Kenneth S. Norris, Marineland of the Pacific, Marineland, California.

Immediately after the opening session the members and their spouses assembled on the

steps of the Aztec Shops on the campus for the annual group photograph. During the afternoon the ichthyologists met in joint session with the American Society of Limnology and Oceanography for a symposium on "Fisheries Oceanography." Meanwhile the herpetologists, under the chairmanship of MR. CHARLES M. BOGERT, devoted their attention to a symposium on "Adaptations of Reptiles and Amphibians to Desert Environments" at which the following papers were given:

Reproductive Adaptations of Amphibians for Desert Life. W. Frank Blair, University of Texas, Austin.

The Ecology of a Desert Population of *Rana pipiens*. Rodolfo Ruibal, University of California, Riverside.

Embryonic Adaptation to Temperature in Desert Anurans. Richard G. Zweifel, American Museum of Natural History, New York.

Adaptations and Adjustments of Desert Reptiles and Amphibians to Environmental Stress. Charles H. Lowe, Jr., University of Arizona, Tucson.

During the early evening members of the Board of Governors and their spouses assembled at the home of Dr. and Mrs. LAURENCE M. KLAUBER where they were treated to a delicious and sumptuous buffet supper. Immediately thereafter the Governors adjourned to the San Diego Natural History Society for their annual meeting. A total of forty-four Governors and several guests were present.

With PRESIDENT BAILEY in the Chair, MR. ROGER CONANT, the Secretary, announced that expressions of regret for absence had been received from the following Governors: HOWARD K. GLOYD, GORDON GUNTER, COLEMAN J. GOIN, RICHARD HIGHTON, ERNEST A. LACHNER, and M. GRAHAM NETTING.

The minutes of the 1958 meeting were approved as published in *Copeia* 1958(4):346-352.

Ten persons were elected to the Board of Governors for the Class of 1964, as follows: ROLF L. BOLIN, DANIEL M. COHEN, W. I. FOLLETT, WILLIAM A. GOSLINE, ERNEST A. LACHNER, ALAN E. LEVITON, JAMES A. PETERS, RODOLFO RUBIAL, CHARLES E. SHAW, and ROBERT C. STEBBINS. WILLIAM H. WOODIN was elected to fill a vacancy in the Class of 1960.

A suitable memorial for John T. Nichols was discussed, and it was unanimously agreed that each issue of *Copeia* hereafter should have "Founded in 1913 by John Treadwell Nichols" imprinted upon its masthead. Inasmuch as a special Nichols number of *Copeia* had been published in 1933, it was the consensus that no memorial number would now be needed. DR. GILES W. MEAD reported the existence of a bibliography of Nichols' papers, the ichthyological

and herpetological portions of which perhaps could be printed in *Copeia*. Because of the considerable length of the list, DR. MEAD was requested to investigate the possibility of publication elsewhere before the list was accepted for *Copeia*.

The deaths of two Honorary Foreign Members, DR. PAUL CHABANAUD and DR. A. VEDEL TÄNING were reported. DR. CURT KOSWIG, of Germany, and N. B. MARSHALL, of Great Britain, were elected to fill the vacancies.

Under the prompting of Editor-in-Chief PHILIP W. SMITH and several other members, the Board of Governors was requested to formulate an obituary policy for *Copeia*. After discussion it was agreed, with only one dissenting voice, that subsequent to the publication of the Karl P. Schmidt Memorial Number later this year, there should be no further memorial numbers of the journal. The Governors thus voted by far more than the necessary two-thirds majority to abolish Article X of the Society's by-laws which read as follows:

"Article X: Anniversary and Memorial Numbers of *Copeia*.

"Nominations pertaining to Anniversary and Memorial numbers shall be submitted in writing to the President at least three months in advance of the annual meeting. Such nominations shall be studied by a committee consisting of the officers of the Society, and if approved by this committee, the nominations shall be submitted to the Board of Governors at the annual meeting for its action. If the committee is not in favor of the nomination, the Secretary shall so inform the person making the original proposal."

The Governors also voted to change the numbers of "Articles XI, XII and XIII" to Articles X, XI, and XII, respectively.

It was further agreed that the deaths of all members of distinction should be recorded in the "Editorial Notes and News" section of *Copeia*, and that a photograph and a page of biographical information should be published in the journal in the case of deaths of persons who had made noteworthy contributions to ASIH.

A contribution of fifty pounds to the Zoological Society of London for aid in the publication of the *Zoological Record* was approved. This represents an increase of five pounds over the sum contributed last year.

The invitations from the University of Texas to meet in Austin in 1961 and from the U. S. National Museum to meet in Washington, D. C., in 1962 were unanimously accepted.

Attention was called to the fact that the holding of meetings in late June works a hardship

upon academic members who must teach summer school. MR. LOREN P. WOODS, of the Chicago Natural History Museum, our host institution for 1960, stated that he would undertake to investigate the possibility of advancing the dates of next year's meetings (now set for June 27 to 29, inclusive) by about two weeks.

The report of the Vice-President for Conservation (in the absence of DR. M. GRAHAM NETTING) was read by MR. NEIL RICHMOND. DR. NETTING commented upon the publication of the Society's resolution opposing the indiscriminate use of poisonous sprays in an attempt to eradicate the fire ant, stating that the response from sister societies had been disappointingly poor. He stated that apparently it would take fatalities to human beings or some other well-publicized disaster to awaken the public and legislators to the dangers of spray programs. DR. JOHN C. BRIGGS, Vice-President for Finance, stressed the necessity for increasing the Society's endowment funds so that additional moneys will be available in the future for the publication of a larger, considerably-expanded *Copeia*. He urged individuals who have had contacts with philanthropic organizations which might be interested to advise him about procedures. DR. JAMES KEZER, Vice-President for Membership, asked for suggestions on how an appeal for memberships or subscriptions to *Copeia* could be directed toward amateur herpetologists, especially those who are already members of the considerable number of amateur organizations that have sprung into existence during the past several years.

The Governors then grappled with the problem of the publication of *Copeia*. First, DR. JAMES A. OLIVER, Chairman, reported for the Committee on the Publication Costs of *Copeia*. DR. OLIVER reminded those present that his Committee had been instructed to investigate further the possibility of having our journal published by the University of Texas Press. He reported that the Texas Press could, indeed, save our Society an appreciable amount of money, but that a stipulation had been made that the editor of *Copeia* would have to be a member of the staff of the University of Texas in order for *Copeia* to qualify. Since none of our members in Austin had volunteered to undertake this assignment, it was the recommendation that the matter be tabled and that the committee be discharged. It was so ordered.

PRESIDENT BAILEY explained that it had become necessary for the former Editor-in-Chief, DR. FRED R. CAGLE, to resign and that, since the Nominating Committee had been unable to find a successor, he (DR. BAILEY) had appointed DR.

PHILIP W. SMITH as interim Editor-in-Chief for the year 1959. The Executive Committee had approved the expenditure of the sum of \$500 for secretarial assistance for DR. SMITH in the preparation of the first two issues of the year. The Governors unanimously approved an expenditure of \$1,000 for the purpose for the year 1959, this amount to include the \$500 already authorized by the Executive Committee.

PRESIDENT BAILEY further explained that, in order to have some suggestions available for the consideration of the Governors, he had appointed an *ad hoc* committee composed of former editors of *Copeia* at the University of Michigan. This committee had recommended a return to the former plan of having three editors, one for ichthyology, one for herpetology, and a third who might be called Managing Editor. The committee's suggestions were based upon the fact that the work would thus be divided among three persons, and no subsidy would be required for secretarial help. This plan was vigorously discussed. Since its implementation would be dependent upon the passage of an amendment to the Society's Constitution, the following amendment was offered by the Committee: Be it resolved that Sections 1 and 7 of the Constitution be amended to read as follows:

"Section 1. The officers of the Society shall be: HONORARY PRESIDENT HELEN T. GAIGE for life. A President who shall automatically assume the duties of this office for a one-year term immediately following his term as President-Elect. The President-Elect shall serve a one-year term; the office shall alternate annually between an ichthyologist and a herpetologist; the President-Elect shall be ineligible to succeed himself until two years shall have elapsed from the end of his term as President. Three Vice-Presidents elected for a one-year term but eligible for immediate re-election. A Treasurer, a Secretary, and a Publications Secretary, all of whom may be re-elected annually but who may serve unlimited consecutive terms. A Managing Editor, an Ichthyological Editor, a Herpetological Editor, and an editorial board of eleven members, of whom one shall be Index Editor, five shall be ichthyologists, and five shall be herpetologists, each of whom shall be elected annually but who may serve unlimited consecutive terms."

"Section 7. The Executive Committee shall consist of the President, Vice-Presidents, Secretary, Treasurer, and Managing Editor."

This was passed by the necessary two-thirds majority. (Note should be made that the new amendment also eliminated the name of the late

John Treadwell Nichols who had been an Honorary President for life.)

In conjunction with the editorial problem, DR. ARNOLD B. GROBMAN reported that the American Institute of Biological Sciences had acquired a staff to begin preliminary work on organizing an office to help member societies in publishing their journals. Use of such a service could considerably reduce and simplify the work of the editors. DR. GROBMAN pointed out that if ASIH used the assistance of AIBS in this respect, the Society might find it necessary to change its editorial structure again in the near future.

DR. N. BAYARD GREEN, Publications Secretary, reported receipts of \$1775.35 during 1958 for back numbers of *Copeia* and other publications of the Society and that this is an all-time high for income from this source. DR. GREEN received a vigorous round of applause for his continued excellent execution of the duties of his office.

DR. JAMES E. BÖHLKE, the Treasurer, presented his report as follows:

Financial Report for Calendar Year 1958

CHECKING ACCOUNT

Balance on hand, Central-Penn National Bank,
Philadelphia, January 1, 1958. \$ 7,466.86

RECEIPTS (CURRENT)

Memberships	6,807.68
Subscriptions	4,621.50
Sale of publications by Publications Secretary	998.32
Sale of <i>Copeia</i> and <i>Dopeia</i> by Secretary	26.50
Sale of Check List	6.50
Sale of Common Names Check List	19.10
Interest from Government bonds	250.50
Charges for <i>Copeia</i> mailing list	79.33
Petty cash refund from previous secretary	2.52
Group picture sales at Bloomington (further costs reduced actual profit to 2.25)	23.25
Central-Penn National Bank—credit memos	10.01
Sale of \$1000 Government Bond	1,000.00
Contributions	
Paul K. Anderson (Revolving Research Fund)	100.00
Carl L. Hubbs (Western Division Prizes)	20.00*
A. W. Ebeling (contribution toward publication of paper 'Dentition in Mullets')	100.00
	220.00
Contributions to the Schmidt Memorial Number of <i>Copeia</i>	746.00

RECEIPTS (FUNDS FROM PREVIOUS TREASURER)

Balance in Revolving Research Fund—Jan. 21, 1958	240.25
1957 Year-end balance checking account	1,307.10
	\$23,825.42

* An additional \$20.00 was contributed and presented directly to the prize winners by Hubbs.

SUMMARY OF 1959 MEETINGS

359

EXPENDITURES AND DISBURSEMENTS

Publication of *Copeia*

1957, no. 4.....	\$2,407.83
1958, no. 1.....	1,719.54
1958, no. 2.....	1,996.39
1958, no. 3.....	2,044.61

Dues, A.I.B.S.....	8168.37
Transportation of old secretarial files to Publ. Secretary.....	808.00
Stenographic Services, Bloomington.....	5.76
Printing of Group Photographs, Bloomington.....	15.00
Contribution of 45 pounds to Zoological Society of London to assist in publication of 'Zoological Record'.....	21.00
Printing.....	126.00
Secretarial Services, Philadelphia.....	494.20
Postage.....	150.00
Secretaries.....	322.67
Past Treasurer.....	1.36
Editor.....	200.00

Purchase of \$1000 government bond (replacement)	524.03
Bank charges.....	1000.00
Supplies—Secretary.....	.45
Western Division Mailing List.....	16.00
Binding Editor's set of <i>Copeia</i>	5.20
Phone calls—Secretary.....	4.12
Refunds of dues paid in excess.....	12.28
Student Prizes.....	18.00

Stoye

Richard E. Etheridge (1st prize, Herpetology).....	25.00
Wayne H. McAlister (2nd prize, Herpetology).....	15.00
Bruce B. Collette (1st prize, Ichthyology).....	25.00

Western Division

Wallace G. Heath (1st prize, Ichthyology).....	20.00
--	-------

85.00

Total Expenditures.....	\$11,453.41
Balance on hand, December 31, 1958.....	
Central-Penn National Bank, Philadelphia.....	12,372.01
Total.....	\$23,825.42

ENDOWMENT FUND

Balance on hand, January 1, 1958.....	
Central-Penn National Bank, Philadelphia.....	\$ 450.33
First Federal Savings and Loan, Gainesville.....	2428.64
Received from Life Members.....	2878.97
Interest.....	1000.00
Total.....	\$ 3989.05
Balance on hand, December 31, 1958.....	
Second Federal Savings and Loan, Philadelphia.....	\$ 3989.05

REVOLVING RESEARCH FUND

(A part of the General Checking Account)

Balance on hand, January 1, 1958.....	
Florida Bank of Gainesville.....	\$ 240.23
Received from Paul K. Anderson.....	100.00
Total.....	\$ 340.23
Balance on hand, December 31, 1958.....	
Central-Penn National Bank, Philadelphia.....	\$ 340.23

The Secretary read the report of the Auditing Committee, and this was approved and ordered filed.

The Treasurer further reported that, because of certain savings and because the budget for *Copeia* had not been spent in full during the past two years, there was a temporary surplus of some \$5,000 in the Society's checking account. It was not expected that such a favorable condition would be repeated in the foreseeable future. The Treasurer and the Vice-President for Finance jointly proposed that this money be invested as follows: \$1000 in the Endowment Fund; \$2000 in the Massachusetts Investors Trust; and \$2000 in a savings account. The funds in the last two mentioned categories could be withdrawn upon short notice if they should be needed. These recommendations were approved unanimously.

SECRETARY CONANT reported that the Society, as of June 1, 1959, had 1,130 members and 472 subscribers. Copies of *Copeia* are sent to all fifty states and to fifty-two foreign countries. He also reported that dues collections for the current "fiscal" year are running nearly \$1,500 ahead of the previous "fiscal" year. A total of 163 new members and subscribers have been obtained since the last annual meeting of the Society held in Bloomington, Indiana, in August of 1958, a considerable increase. As a result of the economies effected in *Copeia*, the cost per page, based upon a comparison of the total costs for the years 1957 and 1958, indicated a saving of \$1.60 per page.

DR. EARL S. HERALD, President of the Western division of ASIH, gave a report for his group pointing out that most of its activities for the past year have been centered around preparations for the annual meeting of the national Society in San Diego.

Reports were received from committees as follows: (1) Committee on Zoological Nomenclature, DR. HOBART M. SMITH, Chairman. The controversy concerning the use of *Trionyx* versus *Amyda* for softshell turtles has been referred to the International Commission for Zoological Nomenclature. (2) Committee on Traffic in Venomous Snakes, DR. JAMES A. OLIVER, Chairman. The U. S. Fish and Wildlife Service, of the De-

partment of the Interior, has shown interest in seeking standby legislation to control the importation of venomous snakes and other so-called noxious animals in case such action may be needed. MR. CONANT and other members of the American Association of Zoological Parks and Aquariums attended a hearing in Washington during which it was recommended (and apparently accepted by the Fish and Wildlife people) that provisions be made for the importation of venomous snakes for zoos, museums, research centers, etc. in case their importation should otherwise be restricted. (3) Committee to Investigate the Translation of Foreign Biological Literature, DR. DONALD P. DE SYLVA, Chairman. Numerous books and monographs have been selected for translation. The Chairman would appreciate communications from members who have translations available in their files. If any of these are in typewritten form, arrangements can be made to duplicate them. Efforts are being made to obtain funds for translations and publication of them.

After the report on venomous snakes, MR. CLIFFORD H. POPE suggested the possibility of the Society's publishing approved instructions for the treatment of bites from poisonous snakes. It was the consensus of the meeting, however, that whereas the pages of *Copeia* would be open for the publication of such an article under the name of an expert on the subject, the matter was too highly controversial for ASIH to make specific recommendations.

In the absence of DR. NETTING, Chairman of the Nominating Committee, DR. ROBERT R. MILLER presented a tentative report and stated that the Committee had not yet completed its deliberations but that it would be ready to make a full report at the Business Meeting of the Society on Friday.

The Publications Secretary reported that we have some 1,300 copies remaining of the 6th edition of the *Check List of North American Amphibians and Reptiles*, that sales are extremely slow, and it seems unlikely that any further considerable number of copies will be sold at the current price of \$3.25 per copy. The question was raised as to whether it might be advisable to reduce the price or whether the bulk of the remaining copies should be sold to a remainder house. After discussion it was agreed to offer copies for sale at a cost of \$1.50 each, and the Editor-in-Chief was instructed to publish a note to that effect in *Copeia*.

The Secretary was instructed to consult with MR. W. I. FOLLETT, who is an attorney as well as an ichthyologist, and then to copyright the name *Copeia*, the emblem that is imprinted upon

the rear cover of each issue of that journal, and also the 6th edition of the check list of amphibians and reptiles.

A motion was passed unanimously authorizing the President to invite all the Society's Honorary Foreign Members to attend each annual meeting, but the provision was made that no funds should be made available to any Honorary Foreign Member for travel to meetings or for any other purposes.

The Secretary read a memorandum received from AIBS stating, that, after careful investigation, tax exemption had been given to that organization by the U. S. Treasury Department. The Treasury Department requires, however, that AIBS amend its Certificate of Incorporation to state more clearly the functions and purposes of the Institution. It is necessary for each full member society to ratify the change. The new wording recommended by AIBS was unanimously approved.

A suggestion was made that the Society charge up to \$75 for the use of its mailing list for commercial purposes. The amount to be charged was left to the discretion of the Secretary who was also instructed to collect all that "the traffic would bear."

As a corollary to the partitioning of the office of Editor-in-Chief, the Governors discussed the duties of the Secretary, who, in addition to the functions usually performed by that office, must also notify all members and subscribers when new payments are due, collect moneys, record dues payments, etc. It was suggested, but no action was taken, that when the present incumbent goes out of office some plan might be effected either to transfer such functions to the office of Treasurer, where some Governors thought they might more appropriately be assigned, or that a new and separate office of Recording Secretary be created.

EVENTS OF THURSDAY, JUNE 18

The herpetologists, under the chairmanship of DR. RAYMOND B. COWLES, continued their symposium on "Adaptations to Desert Environments" by listening to the following papers:

- Relict Populations of the Chihuahuan Desert.** William W. Milstead, Texas Technological College, Lubbock.
Reptile Denning Adaptation to Desert Life. Angus M. Woodbury, University of Utah, Salt Lake City.
The Interaction of Structure, Physiology, and Behavior in the Thermoregulatory Adaptations of Lizards. C. M. Bogert, American Museum of Natural History, New York.
Zoogeography and the Adaptations of Desert Reptiles. Kenneth S. Norris, Marineland of the Pacific, Marineland, California.

Mean
sessions
America
phy. Af
assembl
KEZER,

Multiple
Atlanti
and Fre
Brunsw
The Res
African
Stebbl
Remarks
ulosun
erick R
Vine Sna
lgar an
field, IL
The Stat
Taylor
Ann Ar
The Chi
Correc
gene.
Oxidativ
versity
The Crit
and S
Califor
Influenc
Robert
Relation
E. Pot
Utilizat
Euryce
Gorbn
lumbia
The Eff
Scelop
James
eley.
Heart R
trocar
Midw
Some N
Color.
Photot
lege, M
The Phy
Santa

At th
J. C. B
papers:

A High
ated v
Ronah
ing), S
Intra-a
of the
sity of
Variatio
acters
Collet
System
D. M
couver

Meanwhile the ichthyologists continued their sessions on "Fisheries Oceanography" with the American Society of Limnology and Oceanography. After the noon recess the herpetologists reassembled, under the chairmanship of Dr. JAMES KEZER, to hear miscellaneous papers as follows:

Multiple Nesting and Clumped Emergence to Nest by Atlantic Loggerhead Sea Turtles. David K. Caldwell and Frederick H. Berry, U. S. Fish and Wildlife Service, Brunswick, Ga.

The Results of Stirrnorganeotomy in Tadpoles of the African Frog, *Pyxicephalus delalandis*. Robert C. Stebbins, University of California, Berkeley.

Remarks on the Biology of *Ambystoma tigrinum nebulosum* with Especial Reference to Neoteny. Frederick R. Gehlbach, Cornell University, Ithaca.

Vine Snake Feeding with *Anolis* as Prey. Robert Snedigar and George Rabb, Chicago Zoological Park, Brookfield, Illinois.

The Status of the Pliocene Lizard, genus *Eumecoides* Taylor. Richard Etheridge, University of Michigan, Ann Arbor.

The Chromosome Number of *Proteus anguineus*: A Correction. James Kezer, University of Oregon, Eugene.

Oxidative Metabolism in Lizards. Velma J. Vance, University of California, Los Angeles.

The Critical Thermal Maxima of Western Ambystomids and Salamandrids. James D. Anderson, University of California, Berkeley.

Influence of the Third Eye on Activity in Night Lizards. Robert Glaser, University of California, Berkeley.

Relationships of Texas Neotenic Plethodontids. Floyd E. Potter, Jr., University of Texas, Austin.

Utilization of Radiolodine by the Neotenic Salamander, *Eurycea tynerensis*. Harold A. Dundee and Aubrey Gorman, Tulane University, New Orleans, and Columbia University, New York.

The Effect of Acclimatization on Thermoregulation in *Sceloporus occidentalis*. Daniel C. Wilhoft and James D. Anderson, University of California, Berkeley.

Heart Rates of Intact Unanesthetized Snakes by Electrocardiogram. Gary K. Clarke and Thomas I. Marx, Midwest Research Institute, Kansas City, Mo.

Some Native and Exotic Amphibians and Reptiles in Color. Problems and Techniques in Herpetological Photography. Nathan W. Cohen, Modesto Junior College, Modesto, California.

The Phylogeny of the Emblemariinae. John Stephens, Santa Barbara College, Goleta, California.

At the same time the ichthyologists, with Dr. J. C. BRIGGS presiding, listened to the following papers:

A High Mortality of Warm-water Game Fishes Associated with Heavy Parasitism. Andrew C. Olson, Jr., Ronald W. Crawford, and Maurice H. Getty (presenting), San Diego State.

Intra- and Interspecific Patterns of Variations in Fishes of the Family Hexagrammidae. Jay C. Quast, University of California, La Jolla.

Variation and Systematic Significance of Meristic Characters in the Darter Subgenus *Holepis* Bruce B. Collette, Cornell University, Ithaca.

Systematics of the Dolly Varden, *Salvelinus malma*. J. D. McPhail, University of British Columbia, Vancouver.

The Tripterygiidae and New World Zoogeography. Richard H. Rosenblatt, University of California, La Jolla.

Artificial Spawning Boxes for Largemouth Bass, *Micropterus salmoides*, in a Multiple Purpose Reservoir. John T. Salyer, San Diego State.

The Distribution of the Bathypelagic Fishes of the Genus *Melamphaes* in the Eastern North Pacific Ocean. Alfred W. Ebeling, University of California, La Jolla.

Is the Lahontan Cutthroat Trout, *Scioia clarki henshawii*, Extinct? Robert J. Behnke, University of California, Berkeley.

In Situ Observations of the Deep Sea Environment Using Bathyscaphes. Andreas B. Rechnitzer, U.S.N. Electronics Laboratory, San Diego.

Evolution of the Amblyopsidae (Cyprinodontiformes, Amplyopsidae): Absolute and Relative Growth Rates. Thomas L. Poulson, University of Michigan, Ann Arbor.

During the evening the ichthyologists transferred their activities to the Scripps Institution of Oceanography, at La Jolla, where they conducted two separate but concurrent sessions. The first of these, with Mr. SAM HINTON presiding, was devoted to an "Aquarium Symposium" where the following subjects were presented:

Observations on the Behavior of Captive Pacific Pilot Whales. David Brown, Marineland of the Pacific, California.

Growth Records of Certain Marine Animals in Captivity. F. G. Wood, Jr., Marineland, Florida.

Maintenance of Sharks in Captivity. Eugenie Clark, Cape Haze Marine Laboratory, Placida, Florida.

The Relative Ability of Various Species to Survive under Aquarium Conditions. Murray Newman, Vancouver Public Aquarium, Vancouver, B. C.

Problems in Redesigning a Multisystem Aquarium within an Existing Structure. Earl S. Herald and Robert P. Dempster, California Academy of Sciences, San Francisco.

The National Aquarium. Craig Phillips, U. S. Fish and Wildlife Service, Washington, D. C.

Optical Properties of Aquaria and Their Applications to Lighting and Design. William Kelley, Cleveland Public Aquarium, Cleveland, Ohio.

Candiru (Parasitic Pygid) Feeding on Gills of Living Goldfish. (Filmed for the first time.) Daniel Moreno, Cleveland Public Aquarium, Cleveland, Ohio.

Public Aquarium Workshop, A Project of the American Association of Zoological Parks and Aquariums. William Kelley, Cleveland Public Aquarium, Cleveland, Ohio.

General discussion of exhibit labels and aquarium instructional techniques.

Dr. BOYD W. WALKER served as Chairman of the other meeting where the following papers were given:

A Contribution to the Biology of the Grouper *Epinephelus merra* of the Society Islands. John E. Randall, Virgin Islands National Park.

First Known Sinistral Examples of *Microstomus pacificus* (Lockington) and *Glyptocephalus zachirus* Lockington, Pleuronectid Fishes of Western North America, with Meristic Data. W. I. Follett, California Academy of Sciences, San Francisco; Ralph B. McCormick, California Department of Fish and Game,

- Eureka, and E. A. Best, California Department of Fish and Game, Stanford.
- The Draconettidae: A Review of the Family. John C. Briggs and Frederick H. Berry, University of British Columbia, Vancouver, and U. S. Fish and Wildlife Service, Brunswick, Georgia.
- Distributional Patterns of the Myctophid Fishes. Rolf L. Bolin, Hopkins Marine Station, Pacific Grove.
- Death of a Fish Fauna in a Multiple Purpose Reservoir. John W. Wilton and R. W. Crawford, San Diego State College.
- Ontogenetic Change in Color Pattern and General Appearance Exhibited by the Short Big-eye, *Pseudopriacanthus altus* (Gill). David K. Caldwell, U. S. Fish and Wildlife Service, Brunswick, Georgia.
- Comments on Argentinoid Fishes. Daniel M. Cohen, U. S. Fish and Wildlife Service, Washington, D. C.
- Ecology of the Swordfish (*Xiphias gladius* L.) in Northern Chile, April-May, 1956. Donald P. deSylla, University of Delaware, Lewes.
- Jaw Structure and Tooth Replacement in the Opaleye, *Girella nigricans* (Ayres), with Notes on Other Species. Kenneth S. Norris and John H. Prescott (presenting), Marineland of the Pacific, Marineland, California.
- Information Gleaned from a Collection of Fossil Otoliths from the San Diego Formation. John E. Fitch, California State Fisheries Laboratory, Terminal Island.
- Morphology and Biology of the Inimous Fishes Belonging to the Suborder Giganturoidea. Vladimir Walters, American Museum of Natural History, New York.

While the ichthyologists were being educated at La Jolla certain of the more ambitious herpetologists made excursions to the desert to try their luck at collecting while cruising the roads in automobiles.

EVENTS OF FRIDAY, JUNE 19

Members and guests of ASIH met in joint session in the early morning. The DOCTORS EDWARD H. TAYLOR and N. BAYARD GREEN served as chairmen. The following papers were given:

- A 13-chromosome Salamander in a 14-chromosome Family. John Earle and James Kezer, University of Oregon, Eugene.
- Man and the Changing Fish Fauna of Southern Arizona. Robert R. Miller, University of Michigan, Ann Arbor.
- Cyclic Behavior of *Sceloporus magister* in an Isolated Controlled Environment. Robert D. Tschirgl and John L. Taylor, University of California Medical Center, Los Angeles.
- Food of Transitional and Young Tarpon, in Relation to the Inundation of a Salt Marsh. Robert W. Harrington, Jr., Florida State Board of Health, Vero Beach.

PRESIDENT BAILEY called the annual Business Meeting of the Society to order at approximately 10:30 AM and requested the Secretary to summarize the discussions and actions taken by the Board of Governors at its meeting on Wednesday evening. Since the two amendments upon which the Governors voted also required action by the members at large, these were read in detail. Both changes, the expunging of Article X from the By-laws (eliminating future Memorial Numbers

of *Copeia*) and the alteration of Article IV of the Constitution (to provide for three editors instead of one) were both passed with the necessary two-thirds majorities.

DR. ARNOLD B. GROBMAN, in the absence of DR. ERNEST A. LACHNER (who is the Society's official representative on the governing board of AIBS), reviewed the preparations AIBS is making to aid member societies in publishing their journals. DR. GROBMAN estimated that it probably would require an expenditure of one dollar or slightly more per member for this service. In view of the fact that we have about 1,100 members and since we had just appropriated the sum of \$1,000 for secretarial aid for the Editor-in-Chief, the AIBS estimate of cost was quite in line with what we are now paying. DR. GROBMAN strongly urged that ASIH take advantage of the AIBS plan when the latter has been placed in operation. He pointed out that, by the expenditure of about one dollar by each member, many of the onerous tasks now devolving upon the editors and the secretary would be assumed by AIBS, thus permitting the above-mentioned officers to devote a much larger portion of their time to research.

PRESIDENT BAILEY, in his capacity as Chairman of the Committee on Common Names for Fishes, spoke briefly about the purpose and progress of his group which is working in very close collaboration with the American Fisheries Society. He indicated that the Fisheries Society would soon publish an up-to-date list of the Committee's recommendations.

DR. ROBERT R. MILLER, Acting Chairman of the Nominating Committee, presented the list of candidates selected by his Committee, and in due course the following were elected:

- President: NORMAN E. HARTWEG (who advanced from President-Elect)
- President-Elect: GEORGE A. MOORE
- Vice-President for Conservation: CHARLES E. SHAW
- Vice-President for Finance: GILES W. MEAD
- Vice-President for Membership: ROYAL D. SUTTKUS
- Treasurer: JAMES E. BÖHLKE
- Secretary: ROGER CONANT
- Publications Secretary: N. BAYARD GREEN
- Managing Editor: DAVID L. JAMESON
- Ichthyological Editor: ROMEO MANSUETI
- Herpetological Editor: ROBERT F. INGER
- Index Editor: RONALD W. CRAWFORD
- Editorial Board:

Ichthyologists: ROLF L. BOLIN, WILLIAM A. GOSLINE, ERNEST A. LACHNER, ROBERT R. MILLER, and EDWARD C. RANEY.

Herpetologists: WALTER AUFFENBERG, HENRY S. FITCH, HOWARD K. GLOYD, CLIFFORD H. POPE, and JAY M. SAVAGE.

PRESIDENT BAILEY appointed the following Committees to serve during 1960:

Nominating Committee: EDWARD C. RANEY, Chairman, WILLIAM M. CLAY, EARL S. HERALD, ROBERT C. STEBBINS, and CHARLES F. WALKER.

Common Names of Fishes: REEVE M. BAILEY, Chairman, ERNEST A. LACHNER, CASIMIR C. LINDSEY, C. RICHARD ROBINS, PHILIP M. ROEDEL, W. B. SCOTT, and LOREN P. WOODS.

Herpetological Common Names: ROGER CONANT, Chairman

Committee to Investigate the Translation of Biological Literature: DONALD P. DE SYLVA, Chairman, FRED R. CAGLE, CARL GANS, TERUYA UYENO, and VLADIMIR WALTERS.

Committee on Traffic in Venomous Snakes: JAMES A. OLIVER, Chairman, ROGER CONANT, SHERMAN A. MINTON, JR., and CHARLES E. SHAW.

Local Committee for Chicago Meeting: ROBERT F. INGER, Chairman, L. P. WOODS and D. DWIGHT DAVIS.

Committee on Zoological Nomenclature: HOBART M. SMITH, Chairman, HERNDON DOWLING, CLARK HUBBS, GILES W. MEAD, JAMES A. PETERS, and NORMAN WILIMOVSKY.

Special Committee for the 50th Anniversary (1963): M. GRAHAM NETTING, Chairman, HELEN T. GAIGE, COLEMAN J. GOIN, and CARL L. HUBBS, and the Managing Editor of *Copeia*, the Secretary of ASIH, and the Treasurer of ASIH.

The two groups met again separately during the afternoon, the ichthyologists, with W. I. FOLLETT presiding, heard the following papers:

A Preliminary Report on Biometric Studies of Tunas (genus *Thunnus*) of the Western North Atlantic. Frank J. Mather, III, Woods Hole Oceanographic Institute, Woods Hole, Massachusetts.

A Description of Fishes Taken in McMurdo Sound, Antarctica, During Operation Deep Freeze IV. Hugh H. DeWitt, Stanford University, Stanford.

The Bathypelagic Fish Family Astronesthidae. Robert H. Gibbs, Jr., Boston University, Boston.

Scute Development in *Caranx crysos*. Frederick H. Berry, U. S. Fish and Wildlife Service, Brunswick, Georgia.

Meristics and Relative Growth of Rainbow Trout, *Salmo gairdneri* Richardson, Cutthroat Trout, *Salmo clarki* Richardson, and Reciprocal Hybrids. Gordon F. Hartman, University of British Columbia, Vancouver.

Notes on Distribution and Reproduction in the Benthonic Intomi. Giles W. Mead, Fish and Wildlife Service, Washington, D. C.

A New Percid Fish From Kentucky. William M. Clay, University of Louisville, Louisville, Kentucky.

New Type of Luminous Organ in Fish. Y. Haneda, Yokosuka City Museum, Yokosuka, Japan.

Contributions to the Systematics of Northwestern Coregonid Fishes. Casimir Charles Lindsey, University of British Columbia, Vancouver.

Variations in the Duration of Gametic Function of Southwestern Darters. Clark Hubbs, University of Texas, Austin.

Concurrently, with Dr. NORMAN E. HARTWEG presiding, the herpetologists heard the reading of the following:

Territoriality and Homing Behavior in the Canyon Lizard, *Sceloporus merriami*. William W. Milstead, Texas Technological College, Lubbock.

Observations on Populations of Amphibians and Reptiles in the Tropical Forest of Negros Island, Philippines. Walter C. Brown, Stanford University, California.

The Breathing Cycle in Snakes—Misapplication of the Term "Apneusis." Harry S. McDonald, University of California, Los Angeles.

Origins and Distribution of the Reptile Fauna of Ecuador, with Colored Photographs of Reptiles and Amphibians of Ecuador. James A. Peters, Comision Fulbright, Apartado 538, Quito, Ecuador.

Color Variants of the Red-legged Frog, *Rana aurora draytoni* Baird and Girard. James P. Mackey and Alan E. Leviton, San Francisco State College and California Academy of Sciences, San Francisco.

Notes on the Reptiles of Saline Valley, Inyo County, California. Benjamin H. Banta, Pomona College, Claremont.

Effect of Some Hormones and Temperature Variation on Melanophores in Some Nocturnal Desert Reptiles—a Preliminary Report. Richard A. Lockwood, Los Angeles.

Comments on Eastern Asiatic Caecilians of the Genus *Ichthyophis*. Edward H. Taylor, University of Kansas, Lawrence.

Observations on Ecuadorian Casque-headed Treefrogs, *Tetraprion jordani*, in Captivity. Richard B. Loomis, Long Beach State College, Long Beach.

"Snarling" and the Feeding Behavior of the Red-bellied Snake. Carl Gans, University of Buffalo, Buffalo, New York.

Comments on African Bufonids. Joseph A. Tihen, University of Illinois, Urbana.

In the early evening the members and guests journeyed to La Jolla for a western style barbecue over which SAM HINTON presided. When everyone had eaten his fill two forms of entertainment were offered: An excellent motion picture film in color entitled "Cruise to the Society Islands," which had been taken by and was personally narrated by JOHN E. RANDALL, and folk singing by SAM HINTON in his own inimitable style.

During the evening two of the Society's committees made their reports. The first was the Stoye Prize Committee for the best student papers in both disciplines; this committee consisted of Dr. ROBERT W. HARRINGTON, JR., Chairman, ROLF L. BOLIN, JOSEPH A. TIHEN, and CHARLES H. LOWE, JR. Prizes were awarded to the following:

In ichthyology:

First Prize, ALFRED W. EBELING, University of California at La Jolla, \$25.

Second Prize, BRUCE B. COLLETTE, Cornell University, \$15.

In herpetology:

First Prize, JAMES D. ANDERSON, University of California at Berkeley, \$25.

Second Prize, VELMA J. VANCE, University of California at Los Angeles, \$15.

The Resolutions Committee, consisting of Dr. EDWARD H. TAYLOR, Chairman, Dr. EUGENIE CLARK, and Dr. FRED BERRY presented its report as follows:

"Whereas the 39th Annual Meeting of the American Society of Ichthyologists and Herpetologists held at San Diego State College and the Scripps Institution of Oceanography, from June 17 to June 21, inclusive, is being concluded and, whereas, under the aegis of PRESIDENT REEVE M. BAILEY, it has been one of the most successful of meetings,

"Be it therefore resolved that the American Society of Ichthyologists and Herpetologists extends its heartfelt thanks and gratitude to the local committee, Dr. DAVID L. JAMESON, Chairman, whose meticulous foresight has provided the Society with the numerous benefits and accommodations of this meeting, together with the following local committee members: Dr. RONALD W. CRAWFORD, Chairman of Facilities Committee; Dr. MERREL A. TAYLOR, Chairman of Registration and Information; Dr. CARL L. HUBBS, General Advisor to Personnel; Mr. SAM D. HINTON, Dr. WILBERT M. CHAPMAN; Mr. JAY C. QUAST; Dr. GRACE L. ORTON; Mr. RICHARD ROSENBLATT; Dr. KENNETH S. NORRIS; Dr. ERIC G. BARHAM; Mrs. BETTY SHOR; Mr. ALFRED W. EBELING; Mr. RICHARD J. KREJSA; Mrs. SALLY KRAUSE; Dr. ELBERT H. AHLSTROM; Mr. ARTHUR O. FLECHSIG; Mr. FREDERICK H. STOYE; and Dr. GEORGE E. LINDSAY, General Chairman of the Pacific Division of the American Association for the Advancement of Science; and

"Be it further resolved that very special thanks be given to Dr. and Mrs. LAURENCE M. KLAUBER, hosts extraordinaires to the Board of Governors, whose knowledge of the better things of life, as provided by the Klaubers enabled the said Governors to endure the lengthy meeting that followed, and

"Be it further resolved that appreciation be extended to Dr. M. BLACKBURN for coordinating activities of the Symposium on Fisheries Oceanography with the American Society of Limnology and Oceanography, and

"Be it also resolved that the Society's appreciation be conveyed to Dr. MALCOLM LOVE, President of San Diego State College, and his associates for the physical facilities they have made available to us, and to Mr. PETER G. TRAPANI, Marine Superintendent, and the officers and crew of the Scripps Institution of Oceanography who are furnishing the mobility for the two weekend trips, and to Dr. CARL L. HUBBS, and his assistants consisting of the following not previously mentioned: CONSTANCE LIMBAUGH, WHEELER NORTH, ROBERT PARKER, JAMES STUART, and ROBERT WISNER, and to Dr. MERREL A. TAYLOR and CHARLES E. SHAW, JOHN SLOAN, JOHN FELLOWS, MICHAEL MERKEL, and CLYDE STRICKLER for assisting with the herpetological field trips, and to SAM D. HINTON and WILBERT M. CHAPMAN for arranging the excellent barbecue on the shore of the Pacific under an almost full moon, and

"Be it further resolved that the American Society of Ichthyologists and Herpetologists owes a debt of gratitude to Dr. FRED R. CAGLE for his great labor in so ably editing *Copeia* for several years, and

"Be it further resolved, that the Society is cognizant of the great loss it has sustained in the recent death of JOHN TREADWELL NICHOLS, the founder of *Copeia* and the moving spirit during the inception of our organization, and

"Be it further resolved, on behalf of the 153 members and thirty-two members' wives from twenty-four states, Canada, and Japan, who registered attendance at this meeting, that an assertion be made of personal awareness of having attended a most extremely interesting and beneficial meeting."

EVENTS OF SATURDAY, JUNE 20, AND
SUNDAY, JUNE 21

The final two days of the meetings were devoted to trips at sea. On Saturday some seventy members boarded a fleet of Scripps vessels and set sail for the Coronados Islands, which lie seven miles off shore and in Mexican territorial waters. Nineteen herpetologists were put ashore on South Coronado Island, where they collected lizards and watched the herds of California sea lions and elephant seals. The ichthyologists meanwhile witnessed a sub-intertidal fish collection demonstration. On Sunday a Scripps vessel took a party to the vicinity of the Coronados Islands over the San Diego Trough to witness collection methods such as are employed in deep waters.—ROGER CONANT, Secretary.

Ancylor
Ancylor
cycloide
Denia
deltae,
diodon
Dracon
elegans
Euinece
Eviotop
filamen
(Gobio
Hemidi
Hyla ro
japonic
johnfit
jolenis
karlsch
Kaupie
kumpe
Labrist
Lestidi
Limno
maxille
mexica
multiv
Natrix
Natrix
Notrof
oregon
Parah
respect
Rhodo
rigida
rigida
Yossall
Sartor
Sartor
schmie
schmie
schmie
shugya
sinicol
storthy
Thori
Thori
Trache
Trache
uranos

abacur
abacur
acanth
acanth
Acanti
bosh
cant
Achter
Aciper
brev
oxy
Acran
Acroch
Acris,

INDEX TO SCIENTIFIC NAMES 1959, Nos. 1-4

NEW NAMES

Ancylopsetta cycloidea, 140
Ancylopsetta kumperae, 143
cycloidea, *Ancylopsetta*, 140
Denia elegans, 31
deltae, *Natrix rigida*, 304
diodontus japonicus, *Kaupichthys*, 293
Draconetta oregona, 129
elegans, *Denia*, 31
Eumeces multivirgatus mexicanus, 57
Eviotops storthynx, 237
filamentosus, *Labrisomus* (*Gobioclinus*), 289
(Gobioclinus) filamentosus, *Labrisomus*, 289
Hemidactylus shugraensis, 198
Hyla rossalleni, 340
japonicus, *Kaupichthys diodontus*, 293
johnfitchi, *Lestidium*, 284
jolensis, *Trachydactylus*, 200
karlschmidtii, *Rhodona*, 207
Kaupichthys diodontus japonicus, 293
kumperae, *Ancylopsetta*, 143
Labrisomus (*Gobioclinus*) *filamentosus*, 289
Lestidium johnfitchi, 284
Limnomedusa schmidtii, 208
maxillabrochus, *Thorius*, 205
mexicanus, *Eumeces multivirgatus*, 57
multivirgatus mexicanus, *Eumeces*, 57
Natrix rigida deltae, 304
Natrix rigida sinicola, 305
Notropis uranoscopus, 7
oregona, *Draconetta*, 129
Parahollandia schmidtii, 223
respectus, *Sartor*, 149
Rhodona karlschmidtii, 207
rigida deltae, *Natrix*, 304
rigida sinicola, *Natrix*, 305
Yossalleni, *Hyla*, 340
Sartor, 148
Sartor respectus, 149
schmidtii, *Limnomedusa*, 208
schmidtii, *Parahollandia*, 223
schmidtii, *Thorius*, 203
shugraensis, *Hemidactylus*, 198
sinicola, *Natrix rigida*, 305
storthynx, *Eviotops*, 237
Thorius maxillabrochus, 205
Thorius schmidtii, 203
Trachydactylus, 199
Trachydactylus jolensis, 200
uranoscopus, *Notropis*, 7

ESTABLISHED NAMES

abacura, *Farancia*, 71, 309
abacura reinwardti, *Farancia*, 71
acanthopoma, *Centrodraco*, 127
acanthopoma, *Draconetta*, 123, 124, 126, 130, 132
Acanthodactylus, 202
boskianus asper, 202
cantoris arabicus, 202
Achteninus, 244
Acipenser
brevirostris, 77
oxyrhynchus, 77
Acranthophis, 45
Acrochordus, 44, 49
Acris, 98

crepitans, 212, 312-314, 325
gryllus, 98
adamanteus, *Crotalus*, 73, 100, 102, 111, 337
adramitana, *Agama*, 199-202
aestivalis, *Hybopsis*, 255
aestivalis, *Hybopsis extrarius*, 342
aestivus, *Opheodrys*, 111
aethiopica, *Candacia*, 246
affinis, *Gambusia*, 255-256
afuerac, *Malacotenus*, 290
Agama
adramitana, 199-202
flavimaculatus, 197-202
jayakari, 197, 202
sinaita, 197, 202
Agkistrodon
contortrix laticinctus, 337
piscivorus, 45
Aipysurus, 49
albopunctatus, *Helcioporus*, 266-269
aleuticus, *Cottus*, 158
allanae, *Rhodona*, 207-208
alleganiensis, *Cryptobranchus*, 178
alleni, *Hyla*, 340
alleni, *Scytopsis*, 340-341
Alligator mississippiensis, 99
Alnus rugosa, 173
Alosa
pseudoharengus, 342
sapidissima, 343-344
alpestris, *Otocoris*, 212
alpestris, *Triturus*, 91
alpinus, *Salvelinus*, 345-346
Alsophylax
blanfordi, 197
(Bunopus) blanfordi, 198
amabilis, *Notropis*, 255-256
Ambystoma, 97-98, 102
cingulatum, 98
jeffersonianum, 171
laterale, 171
maculatum, 170-172
mexicanum, 91
subsalsum, 320
talpoideum, 98
texanum, 98
tigrinum, 98, 313
Amciurus melas, 138
americanus, *Bufo terrestris*, 171, 173-174
americanus, *Homarus*, 228
americanus, *Macrozoarces*, 20
Amphiuma means, 309
americanus, *Bufo terrestris*, 171
ampla, *Makaira*, 245
ampla marlina, *Makaira*, 349
ampla tahitiensis, *Makaira*, 349
Amyda ferox, 101-102
Anas discors, 97
Anchoa mitchilli, 255
anchovia, *Sardinella*, 134
Ancistrodon
contortrix, 73
piscivorus, 73, 100, 102
Ancylopsetta, 139-48
cycloidea, 140, 143, 145, 148
dendritica, 143, 145, 148

- dilecta, 142, 145, 148
kumperae, 143, 145, 147
 quadrocellata, 142, 145, 147
andersoni, Hyla, 265, 312
Anelytropis, 40
Aneides lugubris, 313
Anguilla rostrata, 255-256
angulifer, *Epicrates*, 337
Anniella, 314
Aniella pulchra, 313
Anilius, 41, 46
annularis, *Pomoxis*, 77, 255-256
annulatus, *Emydocephalus*, 49
anogenus, *Notropis*, 119-123
Anolis
 carolinensis, 99, 313
 carolinensis carolinensis, 111
Anomalochilus, 46
anomalum, *Campostoma*, 341
anomalum pullum, *Campostoma*, 162
Anostomus, 148, 151
 anostomus, 151-152
 plicatus, 151
 trimaculatus, 151
anthracinus, *Eumeces*, 103, 313
Antigonia capros, 343
Aplodinotus grunniens, 255-256
apodus, *Lutjanus*, 256
Aprodon corteziensis, 74-75
aquaticus, *Scalopus*, 97, 212
arabicus, *Acanthodactylus cantoris*, 202
arabicus, *Phrynocephalus*, 197, 202
Arbutus, 59
Arenatus mitranus, 202
areolata, *Rana*, 313, 320
argenteus, *Eucinostomus*, 255-256
argenteus, *Petromyzon*, 162
arizonae, *Xantusia*, 313
Artemisia sp., 173
arvalis, *Rana*, 320
Ascapus, 72
 truei, 72
asper, *Acanthodactylus boskianus*, 202
asper, *Cottus*, 156, 157
Aspis cerastes, 202, 327
assimilis, *Gryllus*, 211
Astracis, 111
Astyanax fasciatus, 255-256
Astlosternus robustus, 94
atchafalaya, *Dorosoma petenense*, 298
atherinoides, *Notropis*, 342
atlanticum, *Lestidium*, 288
Atlanta sp., 246
atlanticus, *Kaupichthys*, 293-297
atratus melesagris, *Rhinichthys*, 162
atricaudatus, *Crotalus horridus*, 337
Atriplex spp., 173
atronasus, *Kaupichthys*, 293
atrox, *Crotalus*, 73, 337
attenuatus longicaudus, *Ophisaurus*, 111
attenuatus, *Ophisaurus*, 99, 313
audax, *Makaira*, 245
aurolineatus, *Malacotenus*, 291
australicus, *Heleioporus*, 266, 268-269
australis, *Istiompax*, 349
australis, *Tetrapturus*, 347
avivoca, *Hyla*, 329
aya, *Chaetodon*, 158
azurea, *Hermosilla*, 281, 283

bairdi bairdi, *Cottus*, 162, 341
bairdi, *Cottus*, 20, 341

bairdi, *Microspathodon*, 280, 283
balteatus, *Richardsonius*, 157
barbouri, *Graptomys*, 168-169
barbouri, *Sistrurus miliarius*, 111
Barbus fluviatilis, 138
bardi, *Chionocetes*, 76
bathyopteryx, *Lestidium*, 286-287
bauri, *Terrapene carolina*, 100
bellus, *Dasyatis*, 97, 102
Benthobatis marcida, 74
beryllina, *Menidia*, 80, 255-256
Betulus nigra, 264
bicolor, *Loxocemus*, 337
bidens, *Gnathodolus*, 151
bifrenatus, *Notropis*, 120
bipes, *Rhodona*, 207-208
bispinosus, *Diceratias*, 225-227
bivittatus, *Phython molorus*, 337
blandingi, *Emydoidea*, 171
blandfordi, *Alsophylax*, 197
blandfordi, *Alsophylax*, (Bunopus), 198
Blarina brevicauda, 97
blainvillei, *Phrynosoma*, 313
blennioides, *Etheostoma*, 162, 343
boehlkei, *Malacotenus*, 291
boleosoma, *Gobionellus*, 255-256
Bolyeria, 44-45, 48, 50, 51
Bombina, 326
 bombina, 91, 323
 variegata, 322-325, 327
 variegata variegata, 322
bonasus, *Rhinoptera*, 251
bondi, *Synodus*, 232-236
boreas boreas, *Bufo*, 174
boreas, *Bufo*, 320-321
boreas halophilus, *Bufo*, 315
boskianus asper, *Acanthodactylus*, 202
Bothrocara
 brunneum, 79
 molle, 78
 mollis, 78
 remigerum, 79
 pusillum, 78
brachypterus, *Remoropsis*, 244-248
brachyrhynchus, *Corvus*, 97
brachystoma, *Thamnophis radix*, 52
braminus, *Typhlops*, 42, 47
brasiliensis, *Saurida*, 232-236
braytoni, *Notropis*, 255
brevicauda, *Blarina*, 97
brevilineatus, *Eumeces*, 313
brevirostris, *Acipenser*, 77
brevirostris, *Histiophorus*, 349
brimleyi, *Pseudacris*, 264
brunnea, *Lycogramma*, 79
brunnea, *Maynea*, 78
brunneum, *Bothrocara*, 79
bucciferus, *Labrisomus*, 291
buchanani, *Notropis*, 255
Bufo
 boreas, 320-321
 boreas boreas, 174
 boreas halophilus, 315
 bufo, 320
 calamita, 320-321
 dhufarensis, 197-198
 marinus, 319-320
 melanostictus, 320
 orientalis, 197, 198
 quercicus, 111
 raddei, 320
 spp., 213

terres
 terres
 terres
 viridi
 wood
 bullisi,
 (Bunop

caerule
 Calama
 calamit
 calcarif
 calceus,
 Calotes
 Calla p
 callicep
 calligas
 Calliom
 Calliom
 hima
 lyra,
 valen
 Callisa
 Calosor
 campos
 Campo
 anom
 anom
 camuru
 cana, P
 canarie
 cancriv
 Candac
 aethi
 pach
 Canthe
 canis, M
 cantori
 capito
 capito,
 capros,
 caprod
 Caranx
 Carcha
 Caretta
 caribae
 caribbe
 carinat
 carolin
 carolin
 carolin
 carolin
 carolin
 carolin
 carolin
 Carphe
 carpio,
 carpio,
 Carpio
 carri, L
 carteri
 carteri
 Casare
 castane
 castane
 catarac
 catenif
 catesbe
 Catoste

- terrestris, 98, 102
 terrestris americanus, 171, 173-174
 terrestris terrestris, 111
 viridis, 320
 woodhousei, 317
 bullisi, Etmopterus, 33
 (Bunopus) blandfordi, Alsophylax, 198

 caeruleum, Etheostoma, 20-22, 240-242, 341-342
 Calamaria, 41
 calamita, Bufo, 320-321
 calcarifer, Chamaeleo, 197-202
 calceus, Deania, 32
 Calotes versicolor, 103
 Calla palustris, 173
 callicephalus, Eumeces, 59
 calligaster, Lampropeltis, 211-213
 Callionymidae, 124
 Callionymus, 125
 himantophorus, 123, 124, 125
 lyra, 124
 valenciennesi, 124, 125
 Callisaurus draconoides, 313
 Calosoma sp., 211
 campestris, Lacerta sicula, 336
 Campostoma,
 anomalum, 341
 anomalum pullum, 162
 camurum, Etheostoma, 240-243
 cana, Pseudaspis, 71
 canariensis, Labrisomus, 290-291
 cancrivora, Rana, 320-321
 Candacia
 aethiopica 246
 pachydactyla 246
 Canthon sp., 211
 canis, Mustelus, 275
 cantoris arabicus, Acanthodactylus, 202
 capito capito, Rama, 111
 capito, Rana, 313
 capros, Antigonia, 343
 caprodes, Percina, 341
 Caranx hippos, 256
 Carcharinus leucas, 251-2
 Caretta caretta caretta, 257
 caribaea, Pinus, 111
 caribbea, Saurida, 232-236
 carinata, Elaphe, 68-69
 carolina bauri, Terrapene, 100
 carolina carolina, Terrapene, 171, 174-176
 carolina major, Terrapene, 100
 carolina, Terrapene, 100, 102
 carolinae, Cottus, 341
 carolinensis, Anolis, 99, 313
 carolinensis carolinensis, Anolis, 111
 carolinensis, Microhyla, 99, 102, 263, 313, 320, 326
 carolinensis, Sciurus, 97
 Carphophis, 41
 carpio, Carpiodes, 255
 carpio, Cyprinus, 255
 Carpiodes carpio, 255
 carri, Desmognathus, 111
 carteri collaris, Pristurus, 197-198
 carteri tuberculatus, Pristurus, 197-198
 Casarea, 44-45, 48, 50, 51
 castaneus, Ichthyomyzon, 163
 castaneus, Petromyzon, 162
 cataractae, Rhinichthys, 160-162, 255
 catenifer deserticola Pituophis, 336-337
 catesbeiana, Rana, 99, 171, 212, 312-314, 319-320
 Catostomus
 commersoni commersoni, 162
 macrocheilus, 157
 caurinum, Mylocheilus, 157
 Cavolinia tridentata, 246
 Cemophora, 41
 coccinea, 263
 centralis, Neobatrachus, 266, 268-269
 centrata, Malaclemys terrapin, 257
 Centrodraco acanthopoma, 127
 cepedianum, Dorosoma, 255, 299
 cephalus, Mugil, 252, 255, 256
 Ceramodactylus, 199-200
 doriae, 198
 major, 197-198
 cerastes, Aspis, 202, 337
 Ceratiola, 112
 ericoides, 111
 Cercocarpus ledifolius, 173
 Chaenobryttus
 coronarius, 253-256
 gulosus, 253-256, 342
 Chaenomugil, 276, 283
 Chaetodon
 aya, 158
 eques, 158
 falcifer, 158
 marcellae, 158
 ocellatus, 252
 sedentarius, 252
 Chalcides ocellatus ocellatus, 197-202
 Chamaeleo calcarifer, 197-202
 chapalae, Chirotoma, 80
 Charina, 44
 Cheilomenes lunata, 70
 Chelonia mydas mydas, 257
 Chelydra serpentina serpentina, 171
 chihuahuana, Pinus, 59
 Chionocetes bardi, 76
 Chirotoma
 chapalae, 80
 consocium, 80
 Chilorhinus, 293
 Chrysemys
 picta, 338, 212, 337
 picta marginata, 171
 picta picta, 174-175
 Chrysophrys, 276
 chrysops, Roccus, 16, 77
 chrysoscelis, Hyla femoralis, 329
 chrysoscelis, Hyla versicolor, 329
 Chrysothamnus sp., 173
 chuss, Urophycis, 248-50
 Cichlasoma cyanoguttatum, 255-256
 cinerea, Hyla, 98-99, 309, 312-313, 320
 cinerea, Salamandra, 33, 35-37
 cinereus cinereus, Plethodon, 170-171
 cinereus, Plethodon, 33, 35-37
 cinereus, Synodus, 232-236
 cingulatum, Ambystoma, 98
 cingulatus, Synaptolaemus, 151
 Citharichthys spilopterus, 255-256
 Cladonia, 111
 clamitans melanota, Rana, 171
 clamitans, Rana, 72, 99, 212, 313
 clarki, Pseudacris, 312-313, 266
 clarki, Sceloporus, 313
 climacophora, Elaphe, 68-69
 Clunea harengus, 228-232
 Cnemidophorus, 314
 grahami, 313
 perplexus, 313

- sacki, 313
 sexlineatus, 111, 313-314
 tessellatus, 313
 coccinea, *Cnemidophorus*, 263
 coerules, *Gerrhonotus*, 313
Coleonyx, 313
 variegatus, 314
Colinus sp., 97
 collaris, *Crotaphytus*, 313
 collaris, *Pristurus carteri*, 197-198
 colletti, *Linophryne*, 227
 coloratus, *Echis*, 197, 202
Coluber, 100
 constrictor, 100, 102, 210-214
 constrictor constrictor, 211-212
 constrictor flaviventris, 211, 212
 constrictor priapus, 11, 211-214
 flagellum frenatum, 314
 rigidus, 303
 lemniscatus, 195
 commersoni *commersoni*, *Catostomus*, 162
 compressus, *Ophisaurus*, 111, 113
 concolor *Ichthyomyzon*, 162
 congestum, *Moxostoma*, 255
 consocium, *Chirostoma*, 80
Constrictor, 44
 constrictor, *Coluber*, 100, 102, 210-214
 constrictor flaviventris, *Coluber*, 211-212, 214
 constrictor priapus, *Coluber*, 111, 211-214
 contortrix, *Ancistrodon*, 73
 contortrix, *Heterodon*, 212
 contortrix laticinctus, *Agkistrodon*, 337
 cooperi, *Synaptomys*, 212
 coosae, *Micropterus*, 77
 Coquette, 143
 corais couperi, *Drymarchon*, 111, 337
 cordovae, *Plecotomus*, 276
 Coregonus coulteri, 20, 342
 corais, *Drymarchon*, 100, 102
 cornutum, *Phrynosoma*, 313
 coronarius, *Chaenobryttus*, 253-256
 coronata wagneri, *Tantilla*, 111
 cortezianus, *Aprodon*, 74-75
 Corvus brachyrhynchos, 97
 coulteri, *Coregonus*, 20
Cottus
 aleuticus, 158
 asper, 156, 7
 bairdi, 20, 341
 bairdi bairdi, 162
 carolinae, 341
 ricci, 342
 coulteri, *Coregonus*, 342
 couperi, *Drymarchon corais*, 111, 337
 crassiscutata, *Testudo*, 101
 crenularis, *Tarletonbeania*, 1-7
 crepitans, *Acris*, 212, 312-314, 325
 cristatus, *Triturus*, 91, 94, 95
 crotalina, *Embryx*, 78
Crotalus
 adamanteus, 73, 100, 102, 111, 337
 atrox, 73, 337
 giganteus, 100
 horridus, 73, 337
 horridus atricaudatus, 337
 viridis viridis, 337
Crotaphytus
 collaris, 313
 reticulatus, 313
 wislizenii, 313
 crucifer, *Hyla*, 98-99, 212, 265-266, 312-313, 334
 crucifer crucifer, *Hyla*, 171
 cruentifer, *Omochelys*, 344
Cryptobranchus, 178
 alleganiensis, 178
Cryptotis parva, 97
 cuneus, *Hypopachys*, 313
 curema, *Mugil*, 252-253
 curtus curtus, *Python*, 337
 cyanellus, *Lepomis*, 77, 140, 255-256
 cyanogenys, *Sceloporus*, 261-262
 cyanoguttatum, *Cichlasoma*, 255-256
 cyanophlyctis ehrenbergii, *Rana*, 197
 cyanophlyctis, *Rana*, 320
 cycloidea, *Ancylorsetta*, 143, 145, 148
 cyclopion, *Natrix*, 309
Cylindrophis, 43, 46
 cynogenys, *Sceloporus*, 312-313
Cyprinodon
 variegatus, 255-256
Cyprinus carpio, 255
Cypselurus
 heterurus, 166-167
 luetkeni, 166-167
Daphnia, 241
Dasyatis, 74
Dasypeltis, 48, 69
 scaber, 68
Dasyus bellus, 97, 102
Deania, 30-32
 calceus, 32
 eglantina, 31-32
 elegans, 31-32
 profundorum, 31-32
 quadrspinosa, 31
 dekayi, *Storeria*, 261
 dekayi dekayi, *Storeria*, 172
 dekayi wrightorum, *Storeria*, 261-262
Deirochelys, 100
 delalandei, *Malacocentrus*, 291
 deliciosus, *Natrix*, 7
 deltae, *Natrix rigida*, 204
 deltoidea, *Populus*, 264
 dendritica, *Ancylorsetta*, 143, 145, 147
 dendriticus, *Labrisomus (Gobioclinus)*, 280-290
Dendroaspis, 49
 depressus, *Sternotherus*, 168, 169
 deserticola, *Pituophis catenifer*, 336
 Desmognathus carri, 111
 dhara guentheri, *Tarboophis*, 197, 202
 dhufarensis, *Bufo*, 197-198
 diaboli, *Dionda*, 255
Diadophis, 100
 punctatus, 100, 102
Dicamptodon ensatus, 313
 dilecta, *Ancylorsetta*, 142
 Diceratias bispinosus, 225-227
Diemictylus viridescens viridescens, 170, 313
 diapterus, *Lycodes*, 78
 dilecta, *Ancylorsetta*, 145, 148
 diodontus japonicus, *Kupichthys*, 293, 297
 diodontus, *Kaupichthys*, 293-295
Dionda
 diaboli, 255
 episcopa, 255-256
 nubila, 342
 dipterygia, *Narke*, 74
Dipsosaurus dorsalis, 313
 discors, *Anas*, 97
 dolia triangularum, *Lampropeltis*, 171, 337
 dombraini, *Istiompax*, 349
 doriae, *Ceramodactylus*, 198
Dormitorator maculatus, 255-256

- dormitator, *Gobiomorus*, 256
Dorosoma
 cepedianum, 255, 299
 petenense atchafalaya, 298
dorsalis, *Dipsosaurus*, 313
Draco, 257
Draconetta
 acanthopoma, 123, 124, 126, 130, 132
 oregona, 124–126, 129–132
 hawaiiensis, 127, 132
 pseudoxenica, 126–127, 132
 xenica, 126–127
Drymarchon
 corias, 100, 102
 corais couperi, 111, 337
draconoides, *Callisaurus*, 313
dulcis, *Leptotyphlops*, 42, 47
dubitus, *Thorius*, 205–206
dunni, *Plethodon*, 313

ebisui, *Malacotenus*, 291
ebisui, *Malocetus* *triangulatus*, 291
Echis *coloratus*, 197
Echis *coloratus*, 202
egregius, *Eumeces*, 113
egregius onocrepis, *Eumeces*, 111, 113–115
eglantina, *Deania*, 31–32
ehrenbergii, *Rana* *cyanophlyctis*, 197
Elachistodon, 48, 68–69
Elaphe, 48, 100
 carinata, 68–69
 climacophora, 68–69
 guttata *guttata*, 111
 obsoleta *obsoleta*, 171
 subocularis, 336
Elaps, 41, 44
elegans *gigas*, *Thamnophis*, 52
Eleutherodactylus
 latrans, 313
 ricordi *planirostris*, 111
elongata, *Gila*, 342
elongatum, *Lestidium*, 286–287
elongatus, *Ophiodon*, 19
Elops *saurus*, 255
Embryx *crotalina*, 78
emiliae, *Opsopoeodus*, 119, 121, 342
Emydocephalus, 49
 annulatus, 49
 ijimae, 49
Emydoidea *blandingi*, 171
ensatus, *Dicamptodon*, 313
Entomacrodops, 291
 macropus, 291
Ephedra *viridis*, 173
Epicrates, 41
 angulifer, 337
episocopa, *Dionda*, 255
episopa, *Dionda*, 256
Eptatretus, 166
 stouti, 166
eques, *Chaetodon*, 158
Equus *sp.*, 97, 102
erdmani, *Malacotenus*, 291
erionma, *Johnsonina*, 222–223
erythronota, *Salamandra*, 33, 35–37
esculenta, *Rana*, 319–320
Etheostoma, 20
 blennioides, 162, 343
 bullisi, 33
 caeruleum, 20–22, 240–42, 341–342
 camurum, 240–243
 flabellare, 20–22
 flabellare *lineolatum*, 341
 grahami, 255–256
 lepidum, 23
 maculatum, 19, 20
 nigrum, 20–22
 spectabile, 20–22
 spectabile *spectabile*, 341
 zonale, 342
 zonale *zonale*, 162
Eucinostomus *argenteus*, 255–256
Eumeces, 59, 99, 103, 108, 314
 anthracinus, 103, 313
 brevilineatus, 313
 callicephalus, 59
 egregius, 113
 egregius onocrepis, 111, 113–115
 fasciatus, 103, 106, 313–314
 gilberti, 313
 inexpectatus, 99, 102, 111, 115–118, 313
 laticeps, 99, 103, 313
 multivirgatus, 57–59, 313
 multivirgatus *gaigei*, 58–59
 multivirgatus *mexicanus*, 57–59
 obsoletus, 103, 109, 312–313
 septentrionalis, 313
 septentrionalis *septentrionalis*, 103
 skiltonianus, 103, 313
 tetragrammus, 313
Eunectes, 41
Eupomacentrus, 152, 153, 156
Eurycea, 61
 neotenes, 312
evides, *Percina*, 342
Eviotops, 237–40
 inflatus, 237–240
 storthynx, 237–240
exilis, *Noturus*, 341–342
Extrarius *aestivalis*, *Hybopsis*, 342
extenuatum, *extenuatum*, *Stilosoma*, 111, 113
eyrei, *Heleioporus*, 266–269

faber, *Zeus*, 276
falcifer, *Chaetodon*, 158
Farancia, 41, 71
 abacura, 71, 309
 abacura *reinwardti*, 71
fasciatus, *Astyanax*, 255–256
fasciatus, *Eumeces*, 103, 106, 313–314
fasciata, *Laticauda*, 45
felis, *Galeichthys*, 255
femoralis *chrysocelis*, *Hyla*, 329
femoralis, *Hyla*, 98–99, 102, 111, 312–313
feriarum, *Pseudacris* *nigrita*, 215, 222, 263–266
ferox, *Amyda*, 101–102
fierasfer, *Lycodapus*, 79–80
filamentosus, *Labrisomus* (*Gobioclinus*), 298–299
fiumana, *Lacerta* *melisellensis*, 336
flabellare, *Etheostoma*, 20–22
flabellare *lineolatum*, *Etheostoma*, 341
flagellum *flagellum*, *Masticophis*, 111, 115–118
flagellum *frenatum*, *Coluber*, 314
flagellum, *Masticophis*, 100, 102
flava, *Naja*, 45
flavescens, *Perca*, 77
flavilata, *Rhadinaca*, 100, 102
flavimaculata, *Agama*, 197–202
flavimaculatus, *Agama*, 197
flavipunctatus, *Pristurus*, 197–198
flaviventris, *Coluber* *constrictor*, 211, 12, 14
floridana, *Neotoma*, 97
floridana, *Pseudemys*, 168–170
floridana, *Rhineura*, 99, 102

- floridana, Rhineura, 111, 113
 floridanus, Sylvilagus, 97, 212
 fluviatilis, Barbus, 138
 foetens, Synodus, 232-236
 formosa, Mollieniasia, 255-256
 formosus, Sceloporus, 313
 frenatum, Coluber flagellum, 314
 frenatus, Hemidactylus, 70
 frontalis, Gastropsetta, 145, 147
 Fundulus, 156
 fulvius, Micrurus, 100, 102
 fulvius fulvius, Micrurus, 111
 furcata, Somersia, 291
 furcatus, Ictalurus, 255, 256, 342
 Fusitriton oregonensis, 77
 furcatus, Ictalurus, 255

 gaigei, Eumeces multivirgatus, 58-59
 Galeichthys felis, 255
 gallapavo, Meleagris, 97
 Gambusia affinis, 255-256
 Garmanichthys, 293
 Gastropsetta, 142
 frontalis, 142, 145, 147
 Gecko vittatus, 313
 Geochelone, 101
 geographica, Graptemys, 168-169, 171
 Geomys pinetis, 97
 Geotrupes sp., 211
 geminata, Quercus, 111
 Gerrhonotus
 coeruleus, 313
 kingi, 313
 liocephalus, 313
 multicarinatus, 313
 getulus holbrooki, Lamprozeltes, 337
 giganteus, Crotalus, 100
 gigas elegans, Thamnophis, 52
 Gila elongata, 342
 gilberti, Eumeces, 313
 gilberti, Hypsibolus, 281, 283
 gilli, Malacocetus, 291
 Girella,
 nigricans, 275-283
 gladius, Histiophorus, 349
 gladius, Xiphias, 344
 glauca, Prionace, 245
 Gloiopotes sp., 246
 glomeratus, Paroneirodes, 227
 Glossopetalon spinescens, 173
 glutinosus, Plethodon, 98, 102, 313
 Gnathanodon sp., 246
 Gnathodolus, 148, 150, 151
 bidens, 151
 Gobioclinus, 289
 dendriticus, Labrisomus, 289-291
 (Gobioclinus) filamentosus, Labrisomus, 289-290
 gobio, Labrisomus, 291
 Gobiomorus dormitor, 256
 Gobionellus bolesoma, 255-256
 Gopherus, 101
 polyphemus, 101-102, 111
 gossypinus, Peromyscus, 97
 gracia, Lichanura roscifusca, 172
 gracile, Lestidium, 286
 graciosus, Sceloporus, 313
 graeca, Testudo, 337
 grahamiae, Salvadora, 314
 grahami, Cnemidophorus, 313
 grahami, Etheostoma, 255-256
 grahami, Natrix, 309
 grammicus, Sceloporus, 59, 313

 grandis, Uropeltis, 47
 granulosa, Taricha, 313
 Graptemys, 168
 barbouri, 168-169
 geographica, 168-171
 graptemys, 168
 nigrinoda, 168-169
 pulchra, 168-170
 gratiosa, Hyla, 98-99
 griseus, Varanus, 197
 grossidens, Lycodapus, 79-80
 grunniens, Apodotus, 255-256
 gryllo, Rana, 99, 313
 Grylloides sigillatus, 70
 gryllus, Acris, 98
 Gryllus assimilis, 211
 guentheri, Holaspis, 257
 guentheri, Tarbophis dhara, 197, 202
 gulosus, Chaenobryttus, 253-256, 342
 guppyi, Labrisomus, 291
 guttata guttata, Elaphe, 111
 Gymnodactylus, 199-201
 Gymnothorax
 mordax, 136
 moringa, 133-134, 136
 vicinus, 133-134, 136
 Gyrinophilus, 60-63
 porphyriticus porphyriticus, 60

 haitiensis, Labrisomus, 291
 halophilus, Bufo boreas, 315
 hankinsoni, Hybognathus, 121
 hannah, Ophiophagus, 337
 harengus, Clupea, 228-232
 Harpalus sp., 211
 hasselquistii hasselquistii, Ptyodactylus, 198
 hawaiiensis, Draconetta, 127, 32
 Heleioporus, 266, 268-270
 albopunctatus, 266, 268-269
 australiacus, 266, 268-269
 cyrei, 266, 268-269
 inornatus, 266, 268-269
 psammophilus, 266, 268-269
 Heloderma suspectum, 313
 helveticus, Triturus, 320
 Hemidactylum scutatum, 170
 Hemidactylus, 198
 frenatus, 70
 shugraensis, 198
 turcicus turcicus, 198
 yerburyi, 197, 198
 hecksheri, Rana, 99
 hemidactylum scutatum, 171
 henshawii, Xantusia, 313
 hermosilla, 282-283
 Hermosilla azurea, 281, 283
 Heterodon, 100
 contortrix, 212
 platyrhinus, 71, 100, 102
 simus, 100, 102
 heterodon, Notropis, 119, 121
 heterurus, Cypselurus, 166-167
 himantophorus, Callionymus, 123-125
 Hippoglossoides
 oblonga, 253
 platessoides, 20
 hippos, Caranx, 256
 hispidus, Sigmodon, 97
 Histiophorus
 brevirostris, 349
 gladius, 349

- Holbrookia, 40
 maculata, 313
 propinqua, 313
 texana, 313
 holbrookii, *Lampropeltis getulus*, 337
 holbrookii, *Scaphiopus*, 98, 102
 Hollardia hollardi, 222-224
 hollardi, 224
 Homarus americanus, 228
 Homolopsis, 44
 horridus atricaudatus, *Crotalus*, 337
 horridus, *Crotalus*, 73
 hubbsi polyporosus, *Malacotenus*, 291
 humilis, *Lepomis*, 77
 Hybognathus
 hankinsoni, 121
 placitus, 255
 Hybopsis
 aestivalis, 255
 hyostomus, 342
 xpunctata xpunctata, 342
 extrarius aestivalis, 342
 hydrophila, *Pseudomonas*, 176, 178
 Hyla, 98
 alleni, 340
 andersoni, 265, 312
 arenicolor, 312-313
 avivoca, 329
 cinerea, 98-99, 309, 312-313, 320
 crucifer, 98-99, 212, 265-266, 312-313, 334
 crucifer crucifer, 171, 264
 femoralis, 98-99, 102, 111, 312-313
 femoralis chrysoscelis, 329
 gratiosa, 98-99
 ocularis, 312-313
 phaeocrypta, 98-99
 regilla, 265, 312-313, 317, 320
 rossalleni, 340
 rubra, 340-341
 septentrionalis, 320
 shrevei, 340
 squirella, 98-99, 312-313
 versicolor, 68, 98-99, 265, 312-313, 325-327, 329, 334-335
 versicolor chrysoscelis, 329
 versicolor phaeocrypta, 329
 versicolor sandersi, 329
 versicolor versicolor, 171
 wilderi, 340
 hyostomus, *Hybopsis*, 342
 Hypentelium nigricans, 162
 Hypopachus cuneus, 313
 Hypsoblennius, 281-283
 gilberti, 281, 283
 Ichthymoyzon, 162-163
 castaneus, 163
 concolor, 162
 unicuspis, 163
 Ictalurus
 furcatus, 342
 melas, 255
 punctatus, 255
 ijimae, *Emydocephalus*, 49
 indica, *Narcina*, 74
 indicus, *Istiompax*, 347-349
 indicus, *Makaira*, 349
 indicus, *Non Makaira*, 349
 indicus, *Tetrapturus*, 347
 inexpectatus, *Eumeces*, 99, 102, 111, 115-118, 312
 infulatus, *Eviotops*, 137-140
 inornatus, *Heleioporus*, 266, 268-269
 intermedia, *Siren*, 313
 intermedium, *Lestidium*, 288
 intermedius, *Synodus*, 232-236
 Istiompax, 349
 australis, 349
 dombrai, 349
 indicus, 347-349
 marlina, 245
 japonicus, *Kaupichthys diodontus*, 293, 297
 japonicum, *Lestidium*, 288
 jarrovi, *Sceloporus*, 59, 213
 jayakari, *Agama*, 197, 202
 jeffersonianum, *Ambystoma*, 171
 jemezianus, *Notropis*, 255
 johnfitchi, *Lestidium*, 284-288
 Johnsonina eriomma, 222-223
 jolensis, *Trachydactylus*, 197, 199-200
 jordani, *Lycenchelys*, 78
 jordani metcalfi, *Plethodon*, 72
 jordani, *Plethodon*, 72
 jordani shermani, *Plethodon*, 72
 Juniperus osteosperma, 173
 kalmi, *Pseudacris nigrita*, 263-266
 karlschmidtii, *Rhodona*, 207
 Kaupichthys, 293-295, 297
 atlanticus, 293, 295, 297
 atronasus, 293-296
 diodontus, 293, 295
 diodontus japonicus, 293, 297
 kaupii, *Synaphobranchus*, 295
 kempi, *Lepidochelys olivacea*, 257
 kendalli, *Verma*, 343
 kingi, *Gerrhonotus*, 313
 kumperae, *Ancylorsetta*, 143, 145
 Labrisomus, 289-90
 bucciferus, 291
 canariensis, 290-291
 (*Gobioclinus*) dendriticus, 289-290
 (*Gobioclinus*) filamentosus, 289-290
 gobio, 291
 guppyi, 291
 haitiensis, 291
 nigricinctus, 291
 nuchipinnis, 290-292
 philippii, 290
 trindadensis, 290-291
 Labroides, 244
 Lacerta, 335
 melisellensis, 336
 melisellensis fiumana, 336
 sardoa, 106
 sicala campestris, 336
 laevis laevis, *Xenopus*, 70
 laevis, *Quercus*, 111
 laevis victorianus, *Xenopus*, 70
 laevis, *Xenopus*, 319
 Laevoceratias liparis, 225
 laricina, *Larix*, 173
 Larix laricina, 173
 Lampropeltis, 100
 calligaster, 211-213
 doliata triangulum, 171, 337
 getulus holbrookii, 337
 Lanthanotus, 40
 laterale, *Ambystoma*, 171
 laterale, *Lygosoma*, 116, 313
 Laticauda
 fasciata, 45

- marinus, Bufo, 319-320
 marinus, Petromyzon, 20, 163, 342
 marlina, Istiompax, 245
 marlina, Makaira, 349
 marlina, Makaira ampla, 349
 marlina, Makaira marlina, 349
 marlina, Makaira nigricans, 349
 Marlina marlina, 349
 marlina marlina, Makaira, 349
 marlina tahitiensis, Makaira, 349
 marnocki, Syrrhophus, 68, 313
 martinica, Membras, 80
 Masticophis, 100
 flagellum, 100, 102
 flagellum flagellum, 111, 115-118
 maxillabrochus, Thorius, 204, 205-206
 Maynea brunnea, 78
 pusilla, 78
 mazara, Makaira, 349
 mazara tahitiensis, Makaira, 349
 m'celli, Phrynosoma, 313
 means, Amphiuma, 309
 megalotis, Lepomis, 255, 256
 melanoleucus multivirgatus, Pituophis, 337
 melanoleucus mugitus, Pituophis, 111, 337
 melanoleucus, Pituophis, 100, 102
 Melanoplus spp., 211
 melanostictus, Bufo, 320
 melanota, Rana clamitans, 171
 melas, Ameiurus, 138
 melas, Ictalurus, 255
 meleagrides, Synodus, 232-236
 Melcagris gallapavo, 97
 melisagris, Rhinichthys atratulus, 162
 melisellensis fumanana, Lacerta, 336
 melisellensis, Lacerta, 336
 Membras martinica, 80
 Menidia beryllina, 80, 255, 256
 menidia, 80
 metcali, Plethodon jordani, 72
 mexicanum, Ambystoma, 91
 mexicanus, Eumeces multivirgatus, 57-59
 mexicanus, Malacotenus margaritae, 291
 Microbatrachylus, 203
 Microhyla, 99, 326
 carolinensis, 99, 102, 263, 313, 320, 326
 olivacea, 313, 326
 microlepis, Uromastix, 197, 202
 microlophus, Lepomis, 253-256
 Micropogon undulatus, 25-30, 255, 256
 Micropterus coosae, 77
 salmoides, 11, 255-256
 Microspathodon, 280, 282-283
 bairdi, 280, 283
 Microtus, 211, 213
 ochrogaster, 212
 pennsylvanicus, 170, 172
 Micrurus, 192-196
 fulvus, 100, 102
 fulvus fulvus, 111
 miliarius barbouri, Sistrurus, 111
 miliarius, Sistrurus, 100, 102
 minor peltifer, Sternotherus, 169
 minor, Sternotherus, 168, 169
 minutissimus, Thorius, 205-206
 miopus, Rhodona, 207
 mirabile, Lestidium, 285
 mirabilis, Phenacobius, 342
 misionis, Linnomedusa, 208-210
 mississippiensis, Alligator, 99
 mitchilli, Anchoa, 255
 mitranus, Arenatus, 202
 mitranus, Scincus, 197-202
 miurus, Noturus, 343
 modestum, Phrynosoma, 313
 moilensis, Malpolon, 197-202
 molle, Bothrocara, 78
 Mollienesia
 formosa, 255-256
 latipinna, 255-256
 mollis, Bothrocara, 78
 molurus bivittatus, Python, 337
 monophylla, Pinus, 173
 montana, Thamnosa, 173
 montanus montanus, Pseudotriton, 60
 mordax, Gymnothorax, 136
 moringa, Gymnothorax, 133-139
 Motella, 248
 Moxostoma congestum, 255
 mucronatus, Sceloporus, 313
 Mugil, 276, 283
 cephalus, 252, 255, 256
 curema, 252-253
 mugitus, Pituophis melanoleucus, 111, 337
 multicaudatus, Gerrhonotus, 313
 multiradiatus, Phtheichthys, 244
 multivirgatus, Eumeces, 57-59, 313
 multivirgatus gaigei, Eumeces, 58-59
 multivirgatus mexicanus, Eumeces subsp. nov., 57-59
 musculus, Mus, 212
 Mus musculus, 212
 Mustelus canis, 275
 mydas mydas, Chelonia, 257
 Mylocheilus curinum, 157
 Mylohyus, sp., 97, 102
 myops, Trachinocephalus, 232-236
 Myrmecophaga, 277
 myrtifolia, Quercus, 111
 Myxine glutinosa, 165-166
 nachtriebi, Semotilus margarita, 342
 Naja, 49
 flava, 45
 namaycush, Salvelinus, 20
 narisovalis, Thorius, 205-206
 Narke dipterygia, 74
 Nasisqualus, 31
 Natrix, 303
 cyclopion, 309
 grahami, 309
 rigida, 303, 307
 rigida deltae, 304-310
 rigida rigida, 304, 306-310
 rigida sinicola, 305-310
 septemvittata, 309
 sipedon sipedon, 172
 taxipilota, 45
 Necturus, 339-340
 maculosus, 313, 339
 maculosus maculosus, 170
 nelsoni, Pseudemys, 101
 Neobatrachus, 266-270
 centralis, 266-269
 pelobatoides, 266-269
 pictus, 266
 sutor, 266-269
 wilsmorci, 266-269
 Neoseps, 110-118
 reynoldsi, 110, 112, 118
 neotenes, Eurycea, 312
 Neothunnus macropterus, 245
 Neotoma floridana, 97
 lepida, 172

- nerka, *Oncorhynchus*, 345
Nesippus sp., 246
nigra, *Betulus*, 264
nigricans, *Girella*, 275-283
nigricans, *Hypentelium*, 162
nigricans, *Leptotyphlops*, 47
nigricans, *Makaira*, 349
nigricans *marlina*, *Makaira*, 349
nigricans *tahitiensis*, *Makaira*, 349
nigricinctus, *Labrisomus*, 291
nigrinoda, *Graptomys*, 168-169
nigrita *feriarum*, *Pseudacris*, 215, 222, 263-266
nigrita *kalmi*, *Pseudacris*, 263-266
nigrita *nigrita*, *Pseudacris*, 215, 222
nigrita, *Pseudacris*, 98, 212, 215, 222, 263, 312-313, 326
nigrita *triseriata*, *Pseudacris*, 171, 263-266, 341
nigrita *verrucosa*, *Pseudacris*, 215
nigromaculatus, *Pomoxis*, 19, 77
nigrum, *Etheostoma*, 20-22
Non *Makaira* *indicus*, 349
normani, *Saurida*, 232-236
norvegicus, *Rattus*, 212
notata, *Uma*, 313
Notechis *scutatus*, 45
Nothopsis, 48
Noturus *exilis*, 341
Notropis
amabilis, 255-256
anogenus, 119-123
atherinoides, 342
bifrenatus, 120
braytoni, 255
buchanani, 255
deliciosus, 7
exilis, 342
heterodon, 119, 121
jemezianus, 255
lutrensis, 255-256, 342
ortenburgeri, 120
percobromus, 342
photogenis, 10
proserpinus, 255
topeka, 120
stramineus, 7-8, 10
umbratilis, 342
uranoscopus, 7-10
venustus, 255
Noturus *miurus*, 343
nubila, *Dionda*, 342
nuchipinnis, *Labrisomus*, 290-292
nudum, *Lestidium*, 286-287
Nysius *thymi*, 70
obesus, *Sauromalus*, 313
oblonga, *Hippoglossina*, 253
obscura, *Thamnophis*, 55
obsoleta *obsoleta*, *Elaphe*, 171
obsoletus, *Eumeces*, 103, 109, 312-313
occidentalis, *Platanus*, 264
occidentalis, *Sceloporus*, 313
ocellatus, *Chaetodon*, 252
ocellatus *ocellatus*, *Chalcides*, 197-202
ochrogaster, *Microtus*, 212
octonemus, *Polydactylus*, 255-256
ocularis, *Hyla*, 312-313
Octopus sp., 76
Odocoileus *virginianus*, 97
Odontoclinus, 289
odoratus, *Sternotherus*, 168, 169, 171
Oedipus, 203
olivacea *kempii* *Lepidochelys*, 257
olivacea, *Microhyla*, 313, 326
olivaceus, *Sceloporus*, 313
olivaris, *Pygodictis*, 19, 255-256
Omocheilus *cruentifer*, 344
omostigmum, *Otophidium*, 343
Oncaea sp., 246
Oncorhynchus *nerka*, 345
onocrepis, *Eumeces* *egregius*, 111, 113-115
Opheodrys
aestivus, 111
vernalis *vernalis*, 171
Ophioblennius, 282-283
steindachneri, 276, 280, 283
Ophiodon *elongatus*, 19
Ophiophagus *hannah*, 339
Ophisaurus, 99
attenuatus, 99, 313
attenuatus *longicaudus*, 111
compressus, 99, 111, 113
ventralis, 99, 102, 313
Opsopoeodus *emiliae*, 119, 121, 342
Opuntia, 111
oregona, *Draconetta*, 124, 25, 26, 29, 30-32
oregonense, *Ptychocheilus*, 157
oregonensis, *Fusitriton*, 77
orientalis, *Bufo*, 197, 198
ornata, *Pseudacris*, 98, 312, 325
ornata, *Uta*, 313
ornatus, *Sceloporus*, 313
ortenburgeri, *Notropis*, 120
Oryzomys *palustris*, 97
osseus, *Lepisosteus*, 255
osteochir, *Rhombochirus*, 244-248
osteosperma, *Juniperus*, 173
Otocoris *alpestris*, 212
Otophidium *omostigmum*, 342
oxyrhynchus, *Acipenser*, 77
pachydactyla, *Candacia*, 246
pacifica, *Lycodopsis*, 78
pacificus, *Somniosus*, 76
palearis, *Lycodes*, 78
pallidula, *Thamnophis*, 53
pallidula, *Thamnophis* *sirtalis*, 52-56
pallidus, *Remoropsis*, 244-248
palustris, *Calla*, 173
palustris, *Oryzomys*, 97
palustris, *Pinus*, 111
palustris, *Quercus*, 264
palustris, *Rana*, 99-212, 313
palustris, *Sylvilagus*, 97
Pandarus, 244
Parahollardia, 224
lineatus, 223-225
schmidti, 222-225
Paralepis, 288
Paralichthys, 253
Parathunnus *sibi*, 20
Paroneirodes
glomerosus, 227
weddi, 225-227
parva, *Cryptotis*, 97
parva, *Lucania*, 255-256
pectoralis, *Macrurus*, 78
Pelamis, 49
platurus, 49
pelobatoides, *Neobatrachus*, 266-269
peltifer, *Sternotherus* *minor*, 169
pennatulus *narismagnus*, *Thorius*, 205-206
pennatulus *pennatulus*, *Thorius*, 205-206
pennsylvanicus, *Microtus*, 170, 172
Perca *flavescens*, 77

Percina
 capri
 evid
 phox
 percob
 Perom
 gossy
 perple
 petene
 petene
 Petrom
 arge
 casta
 mar
 phaco
 phaco
 Phenac
 philby
 philip
 Phoca
 photop
 phoxo
 Phragm
 Phryni
 aral
 mac
 Phryni
 Phryni
 blai
 com
 m'c
 moc
 plat
 sola
 Phthe
 line
 mul
 Phyll
 Phyll
 Picea
 picta
 picta
 picta
 pictus
 Pilodi
 Pime
 Pime
 pinet
 pinet
 Pinus
 cari
 chil
 mo
 pal
 pipie
 pipie
 3
 pisciv
 pisciv
 Pituo
 cat
 me
 me
 me
 Pityn
 pin
 Pityn
 placi
 plani
 Plata
 plate
 platu
 Platy

Percina

- caprodes, 341
- evides, 342
- phoxocephala, 342
- percobromus, Notropis, 342
- Peromyscus, 211-213
 - gossypinus, 97
- perplexus, Cnemidophorus, 313
- petenense atchafalaya, Dorosoma, 298
- petenensis, Signalosa, 255
- Petromyzon
 - argenteus, 162
 - castaneus, 162
 - marinus, 20, 163, 342
- phacocrypta, Hyla, 98-99
- phacocrypta, Hyla versicolor, 329
- Phenacobius mirabilis, 342
- philbyi, Uromastix, 202
- philippii, Labrisomus, 290
- Phoca vitulina, 76
- photogenis, Notropis, 10
- phoxocephala, Percina, 342
- Phragmites, 316
- Phrynocephalus
 - arabicus, 197, 202
 - maculatus, 202
- Phrynosoma, 40, 176
 - blainvillei, 313
 - cornutum, 313
 - m'calli, 313
 - modestum, 313
 - platyrhinus, 313
 - solare, 176, 313
- Phtheichthys
 - lineatus, 244, 247, 248
 - multiradiatus, 244
- Phyllobates trinitatis, 72
- Phyllophaga spp., 211
- Picea mariana, 173
- picta, Chrysemys, 212, 337-338
- picta picta, Chrysemys, 174-175
- picta marginata, Chrysemys, 171
- pictus, Neobatrachus, 266
- Pilodictis olivaris, 19
- Pimelipterus, 276
- Pimephales vigilax, 255-256
- pinetis, Geomys, 97
- pinetorum, Pitymys, 212
- Pinus
 - caribaea, 111
 - chihuahuana, 59
 - monophylla, 173
 - palustris, 111
- pipiens pipiens, Rana, 171
- pipiens, Rana, 68, 99, 102, 171, 176, 212-213, 263, 312-313, 315-321
- piscivorus, Agkistrodon, 45
- piscivorus, Ancistrodon, 73, 100, 102
- Pituophis, 100
 - catenifer deserticola, 336-337
 - melanoleucus, 100, 102
 - melanoleucus melanoleucus, 337
 - melanoleucus mugitus, 111, 337
- Pitymys
 - pinetorum, 212
- Pitymys sp., 97, 102
- placitus, Hybognathus, 255
- planirostris, Eleutherodactylus ricordi, 111
- Platanus occidentalis, 264
- platessoides, Hippoglossoides, 20
- platurus, Pelamis, 49
- Platyplecturus, 47

- platyrhinus, Heterodon, 71, 100, 102
- platyrhinus, Phrynosoma, 313
- Plecostomus, 276, 282
 - cordovae, 276
- Plethodon, 34
 - cinereus, 33, 35-37
 - cinereus cinereus, 170, 171
 - dunni, 313
 - glutinosus, 98, 102, 313
 - jordani, 72
 - jordani metcalfi, 72
 - jordani shermani, 72
- plicatus, Anostomus, 151
- poeyi, Synodus, 232-236
- poii, Lestidium, 288
- poinsetti, Sceloporus, 261, 313
- Polydactylus octonemus, 255, 256
- polyphemus, Gopherus, 101-102, 111
- polyporus, Malacotenus hubbsi, 291
- Pomolobus pseudoharengus, 230
- Pomoxis
 - annularis, 77, 255, 256
 - nigromaculatus, 19
 - nigro-maculatus, 77
- Populus deltoides, 264
- porphyriticus porphyriticus, Gyrinophilus, 60
- pretiosa pretiosa, Rana, 63-66
- pretiosa, Rana, 65-67, 320
- priapus, Coluber constrictor, 111, 211-214
- Prionace glauca, 245
- Pristurus
 - carteri collaris, 197, 198
 - carteri tuberculatus, 197, 198
 - flavipunctatus, 197, 198
- productus, Lepisosteus, 343
- profundorum, Deania, 31-32
- prolixum, Lestidium, 286-287
- propinqua, Holbrookia, 313
- proserpinus, Notropis, 255
- psammophilus, Heleioporus, 266-269
- Psammophis schokari, 197, 202
- (Psammosaurus) Varanus, 202
- Pseudacris, 98, 264-266, 325
 - brachyphona, 215
 - brimleyi, 264
 - clarki, 266, 312-313
 - nigrita, 98, 212, 215, 222, 263, 312, 313, 326
 - nigrita feriarum, 215, 222, 263-266
 - nigrita kalmi, 263-266
 - nigrita nigrita, 215, 222
 - nigrita triseriata, 171, 263-266, 341
 - nigrita verrucosa, 215
 - ornata, 98, 312, 325
 - streckeri, 312-313, 325
 - triseriata, 325
- Pseudaspis cana, 71
- Pseudemys, 100, 101, 168
- floridana, 101, 102, 168-170
- nelsoni, 101
- scripta, 101, 168-170
- Pseudoeurycea, 203
- pseudoharengus, Alosa, 342
- pseudoharengus, Pomolobus, 230
- Pseudomonas hydrophila, 176, 178
- Pseudotriton, 60-63
 - montanus montanus, 60
 - ruber ruber, 60
- Pseudotsuga, 59
- pseudoxenica, Draconetta, 126-127, 132
- Pteris, 59
 - volitans, 158-160
- Pterolamiops longimanus, 245

- Pteroplatea*, 74
Ptychocheilus oregonense, 157
Ptyodactylus hasselquistii hasselquistii, 198
pulchra, *Anniella*, 313
pulchra, *Graptemys*, 168-170
pullum, *Campostoma anomalum*, 162
pulmonaris, *Thorius*, 203, 205, 206
punctatus, *Diadophis*, 100, 102
punctatus, *Ictalurus*, 255
punctatus, *Lepomis*, 255, 256
punctatus, *Sphenodon*, 313
pusilla, *Maynea*, 78
pusillum, *Bothrocara*, 78
Pyloodictis olivaris, 255, 256
Python, 41, 43-44
 curtus curtus, 337
 molorus bivittatus, 337
 regius, 337
quadrispinosa, *Deania*, 31
quadrocellata, *Ancylorhynchus*, 142, 145, 147
Quercus, 59, 111
 geminata, 111
 laevis, 111
 myrtifolia, 111
 palustris, 264
 virginiana, 111
raddei, *Bufo*, 320
radix brachystoma, *Thamnophis*, 52
Rana, 99, 263, 335
 areolata, 313
 arvalis, 320
 cancrivora, 320-321
 capito, 313
 capito capito, 111
 cathebeiana, 99, 171, 212, 312-314, 319-320
 clavata, 72, 99, 212, 313
 clavata melanota, 171
 cyanophlyctis, 320
 cyanophlyctis chrenbergii, 197
 esculenta, 319-320
 gryllo, 99, 313
 hecksheri, 99
 palustris, 99, 171, 176, 212, 313
 pipiens, 68, 99, 102, 171, 212-213, 263, 312-313, 315-321
 pipiens pipiens, 171
 pretiosa, 65-67, 320
 pretiosa pretiosa, 63-66
 ribibunda, 320
 sevosa, 313
 sylvatica sylvatica, 171
 tarahumarae, 313
 temporaria, 67, 319-320
 tigrina, 320
Ranzania sp., 246
rathbuni, *Typhlomolge*, 312-314
Rattus norvegicus, 212
regilla, *Hyla*, 265, 313, 317, 320
Regina rigida, 303
regius, *Python*, 337
reinwardti, *Farancia abacura*, 71
remigerum, *Bothrocara*, 79
Remora remora, 244-248
Remoropsis,
 brachypterus, 244-248
 pallidus, 244-248
repens, *Serenoa*, 111
Respectus, 151
respectus, *Sartor*, 149, 152
respectus, *Sartor* sp. nov., 149
reticulatus, *Crotaphytus*, 313
reynoldsi, *Neoseps*, 110, 112, 118
Rhadinaea, 100
 flavilata, 100, 102
 floridana, 99, 102, 111, 113
Rhinichthys
 atratus melesagris, 162
 cataractae, 160-162, 255
Rhinocheilus lecontei lecontei, 337
Rhinophis, 47
Rhinoptera bonasus, 251
Rhodona, 207
 allanae, 207-208
 bipes, 207-208
 karlschmidti, 207
 lineata, 207-208
 miopus, 207
 stylis, 207-208
 wilksoni, 207-208
Rhombochirus osteochir, 244-248
ribibunda, *Rana*, 320
ricci, *Cottus*, 342
Richardsonius balteatus, 157
ricordi planirostris, *Eleutherodactylus*, 111
rigida deltae, *Natrix*, 304-305
rigida, *Natrix*, 303, 309
rigida, *Regina*, 303
rigida rigida, *Natrix*, 304, 306-310
rigida sinicola, *Natrix*, 305-310
rigidus, *Coluber*, 303
rigidus, *Tropidonotus*, 303
rivularis, *Taricha*, 313
robustus, *Astylosternus*, 94
Roccos chrysops, 16, 77
roscofusca gracia, *Lichanura*, 172
roscofusca, *Lichanura*, 336
rossalleni, *Hyla*, 340
rostrata, *Anguilla*, 255, 256
ruber ruber, *Pseudotriton*, 60
rubra, *Hyla*, 340-341
rufus, *Lynx*, 97
rugosa, *Alnus*, 173
sacki, *Cnemidophorus*, 313
Salamandra
 cinerea, 33, 35-37
 erythronota, 33, 35-37
Salarias, 276
salmoides, *Micropterus*, 11, 255-256
Salmo trutta, 162
Salvadora grahamiae, 314
Salvelinus
 alpinus, 345-346
 namaycush, 20
sandersi, *Hyla versicolor*, 329
Sanzinia, 45
sapidissima, *Alosa*, 343-344
Sapphirina sp., 246
Sardinella anchovia, 134
sardoa, *Lacerta*, 106
Sarritor, 151
Sartor, 148, 151
 respectus, 149, 150, 152
Saurida
 brasiliensis, 232-236
 caribbea, 232-236
 normali, 232-236
 suspicio, 232-236
sauritus sauritus, *Thamnophis*, 172
Sauromalus obesus, 313
saurus, *Elops*, 255

- saurus, Synodus, 232-236
 scaber, Dasypeltis, 68
 Scalopus aquaticus, 97, 212
 Scaphiopus
 holbrookii, 98, 102
 sp., 320
 Scarus sp., 276
 Sceloporus
 clarki, 313
 cyanogenys, 261-262, 312-313
 formosus, 313
 graciosus, 313
 grammicus, 59, 313
 jarrovi, 59, 313
 mucronatus, 313
 magister, 313
 occidentalis, 313
 olivaceus, 313
 ornatus, 313
 poinsetti, 261, 313
 undulatus, 212, 313
 variabilis, 313
 woodi, 111-112, 115, 313
 schistorhynchus, Laticauda, 49
 schmidt, Limnomedusa, 208-210
 schmidt, Parahollandia, 222-225
 schmidt, Thorius, 203-206
 schokari, Psammophis, 197, 202
 Scincus mitranus, 197-202
 Sciurus carolinensis, 97
 Scolecithrix sp., 246
 scolopax, Macrothamphosus, 160
 scripta, Pseudemys, 101, 168-170
 scutatus, hemidactylum, 170, 171
 scutatus, Notechis, 45
 Scytotis alleni, 340-341
 sedentarius, Chaetodon, 252
 sellardsi, Testudo, 101
 semifasciata, Laticauda, 49
 Semotilus margarita nachtriebi, 342
 septemvittata, Natrix, 309
 septentrionalis, Eumeces, 313
 septentrionalis, Eumeces septentrionalis, 103
 septentrionalis, Hyla, 320
 Serenoa, 111
 repens, 111
 serpentina serpentina, Chelydra, 171
 sevesa, Rana, 313
 sexlineatus, Cnemidophorus, 111, 313-314
 shermani, Plethodon jordani, 72
 shrevei, Hyla, 340
 shugraensis, Hemidactylus, 198
 sibi, Parathunnus, 20
 sicala campestris, Lacerta, 336
 sigillatus, Gryllodes, 70
 Sigmodon hispidus, 97
 Signalosa petenensis, 255
 simile, Lestidium, 387
 simus, Heterodon, 100, 102
 sinaita, gama, 197, 202
 sinicola, Natrix regida, 305-310
 sipedon sipedon, Natrix, 172
 Siren intermedia, 313
 sirtalis pallidula, Thamnophis, 52-56
 sirtalis ssp., Thamnophis, 52
 sirtalis, Thamnophis, 100, 102, 170
 sirtalis sirtalis, Thamnophis, 52, 111
 Sistrurus
 miliarius, 100, 102
 miliarius barbouri, 111
 skiltonianus, Eumeces, 103, 313
 solare, Phrynosoma, 176
 soldatovi, Lycogramma, 78
 Somersia, 291
 furcata, 291
 Somniosis pacificus, 76
 spatula Lepisosteus, 255
 spectabile, Etheostoma, 20-22
 spectabile spectabile, Etheostoma, 341
 Spelerpes, 60
 Sphenodon, 38
 punctatus, 313
 spilopterus, Citharichthys, 255, 256
 spinescens, Glossopetalon, 173
 sp., Octopus, 76
 Squalus, 33
 squirella, Hyla, 98-99, 312-313
 stansburiana, Uta, 313
 steindachneri, Ophioblennius, 276, 280, 283
 Stenodactylus, 199-200
 Sternotherus, 167-169
 depressus, 168, 169
 minor, 168, 169
 minor peltifer, 169
 sternotherus, 168
 Sternotherus odoratus, 168-169, 171
 Stilosoma extenuatum extenuatum, 111, 113
 Stizostedion vitreum, 20
 Storeria, 49
 dekayi, 261
 dekayi dekayi, 172
 dekayi wrightorum, 261-262
 storthynx, Eviotops, 237-240
 stouti, Eptatretus, 166
 stramineus, Notropis, 7-8, 10
 streckeri, Pseudacris, 312-313, 325
 striatus, Tamias, 212
 Sturnella magna, 212
 stylis, Rhodona, 207-208
 subocularis, Elaphe, 336
 subsalsum, Ambystoma, 320
 susceptum, Heloderma, 313
 suspicio, Saurida, 232-236
 sutor, Neobatrachus, 266-269
 sylvatica sylvatica, Rana, 171
 Sylvilagus
 floridanus, 97, 212
 palustris, 97
 symmetricus, Trachurus, 284
 Synaphobranchus kaupii, 295
 Synaptolaemus, 148, 151, 152
 cingulatus, 151
 Synaptomys cooperi, 212
 Synodus
 bondi, 232-236
 cinereus, 232-236
 foetens, 232-236
 intermedius, 232-236
 meleagrides, 232-236
 poeyi, 232-236
 saurus, 232-236
 synodus, 232-236
 Syrrhophus marnocki, 68, 313
 tahitiensis, Makaira ampla, 349
 tahitiensis, Makaira marlina, 349
 tahitiensis, Makaira mazara, 349
 tahitiensis, Makaira nigricans, 349
 talpoideum, Ambystoma, 98
 Tamarix, 316
 Tamias striatus, 212
 Tantilla coronata wagneri, 111

- Tapirus*, 102
veroensis, 97
tarahumarac, *Rana*, 313
Tarbophis dhara guentheri, 197, 202
Taricha
granulosa, 313
rivularis, 313
torosa, 95
Tarletonbeania
crenularis, 1-7
taylori, 1-7
taxispilota, *Natrix*, 45
taylori, *Tarletonbeania*, 1-7
temporaria, *Rana*, 67, 319-320
Terrapene
carolina, 100, 102
carolina bauri, 100
carolina carolina, 171, 174-176
carolina major, 100
terrapin centrata, *Malaclemys*, 257
terrestris, *Bufo*, 98, 102
terrestris americanus, *Bufo*, 171, 173-174
terrestris terrestris, *Bufo*, 111
tessellatus, *Cnemidophorus*, 313
Testudo, 101, 338
crassiscutata, 101
graeca, 337
sellardsi, 101
sp., 101
wilsoni, 101
tetragrammus, *Eumeces*, 313
Tetrapturus
australis, 347
indicus, 347
texana, *Holbrookia*, 313
texanum, *Ambystoma*, 98
Thamnophis, 52, 100
elegans gigas, 52
pallidula, 53
obscura, 55
radix brachystoma, 52
sauritus sauritus, 172
sirtalis, 100, 102, 170
sirtalis pallidula, 52-56
sirtalis sirtalis, 52, 111, 172
sirtalis ssp., 52
sp., 100
montana, 173
Thorius, 203, 205, 206
dubitus, 205-206
macdougalli, 203, 205, 206
maxillabrochus, 204-206
minutissimus, 205-206
narisovalis, 205-206
pennatulus narismagnus, 205-206
pennatulus pennatulus, 205-206
pulmonaris, 203, 205, 206
schmidti, 203-206
troglydites, 205-206
thymi, *Nysius*, 70
tigrina, *Rana*, 320
tigrinum, *Ambystoma*, 98, 313
topeka, *Notropis*, 120
torosa, *Taricha*, 95
Trachinocephalus myops, 232-236
Trachurus symmetricus, 284
Trachyboa, 45
Trachydactylus, 199-200
jolensis, 197, 199-200
Triacanthodes lineatus, 224
triangulatus ebisui, *Malocetus*,
triangulum, *Lampropeltis doliata*, 171, 337
triangulatus, *Malacocetus*, 291
tridentata, *Cavolinia*, 246
trimaculatus, *Anostomus*, 151
trindadensis, *Labrisomus*, 290-291
trinitatis, *Phyllobates*, 72
triseriata, *Pseudacris*, 325
triseriata, *Pseudacris nigrita*, 171, 263-266, 331
Triturus
alpestris, 91
cristatus, 91, 94, 95
helveticus, 320
vulgaris, 91-96, 320
troglydites, *Thorius*, 205-206
Tropidophis, 44-45
leberis, 303
rigidus, 303
tuberculatus, *Pristurus carteri*, 197-198
turcicus turcicus, *Hemidactylus*, 198
truci, *Asaphus*, 72
trutta, *Salmo*, 162
Typha, 316
Typhlomolge rathbuni, 312-314
Typhlops, 42, 47
braminus, 42, 47
Typhlosaurus, 71
lineatus, 70-71
Utrocalamus, 49
Uma notata, 313
umbratilis, *Notropis*, 342
undulatus, *Sceloporus*, 212
unicuspis, *Ichthyomyzon*, 163
undulatus, *Micropogon*, 25-30, 255-256, 313
uranoscopus, *Notropis*, 7-10
Uromastix
microlepis, 197, 202
philbyi, 202
Uropeltis grandis, 47
Urophycis chuss, 248-250
Ursus sp., 97
Uta
ornata, 313
stansburiana, 313
valenciennesi, *Callionymus*, 124, 125
Varanus (*Psammosauros*), 202
griscus, 197
variabilis, *Sceloporus*, 313
variegata, *Bombina*, 322-325, 327
variegata variegata, *Bombina*, 322
variegatus, *Coleonyx*, 313
variegatus, *Cyprinodon*, 255-256
ventralis, *Ophisaurus*, 99, 102, 313
venustus, *Notropis*, 255
Verma kendalli, 343
vernalis vernalis, *Ophedryx*, 171
veroensis, *Tapirus*, 97
verrucosa, *Pseudacris nigrita*, 215
versicolor, *Calotes*, 103
versicolor chrysoscelis, *Hyla*, 329
versicolor, *Hyla*, 68, 98-99, 265, 312-313, 325-327,
329, 334-335
versicolor, *Malacocetus*, 329
versicolor phaeocrypta, *Hyla*, 329
versicolor sanderi, *Hyla*, 329
versicolor versicolor, *Hyla*, 171
vicinus, *Gymnothorax*, 133-139
victorianus, *Xenopus laevis*, 70
vigilax, *Pimephales*, 255, 256
vigilis vigilis, *Xantusia*, 172
vigilis, *Xantusia*, 173, 313
virginiana, *Quercus*, 111

virginianus, *Odocoileus*, 97
 viridescens, *Diemictylus*, 313
 viridescens viridescens, *Diemictylus*, 170
 viridis, *Bufo*, 320
 viridis, *Ephedra*, 173
 viridis viridis, *Crotalus*, 337
 vitreum, *Stizostedion*, 20
 vittatus, *Gecko*, 313
 vitulina, *Phoca*, 76
 volitans, *Pterois*, 158-160
 vulgaris, *Triturus*, 91-96

wagneri, *Tantilla coronata*, 111
 wedli, *Paroneiroides*, 225-227
 weigmanni, *Liolaemus*, 69
 wilderi, *Hyla*, 340
 wilksoni, *Rhodona*, 207-208
 wilsmorei, *Neobatrachus*, 266-269
 wilsoni, *Testudo*, 101
 wislizenii, *Crotaphytus*, 313
 woodhousei, *Bufo*, 317
 woodi, *Sceloporus*, 313
 wrightorum, *Storeria dekayi*, 261-262

Xantusia, 172, 173
 arizoniae, 313
 henshawi, 313
 vigilis, 173, 313
 vigilis vigilis, 172, 313
 xenica, *Draconetta*, 126, 127
 Xenomugil, 276, 283
 Xenopeltis, 40-43, 46, 48
 Xenopholis, 48
 Xenopus, 69-70
 laevis, 319
 laevis laevis, 70
 laevis victorianus, 70
 Xiphias gladius, 344
 xpunctata, *Hybopsis xpunctata*, 342

yerburyi, *Hemidactylus*, 197-198

Zeus faber, 276
 zonale, *Etheostoma*, 342
 zonale zonale, *Etheostoma*, 162

SUBJECT INDEX

- activity patterns, 24-hour, moray, 134-135
- activities, burrowing, larval lampreys, 256-257
- adaptation to brackish water, frogs, 315-321
- adult pomacentrid skull, morphological, 152
- aggressive behavior, *Plethodon*, 72-73
- Alabama River, fish, 7-10
- Albatross, 78, 127, 160
- albinism, flounder, 253
- Aleutian sculpin, 158
- alewife, 342
- algae, 299
- American shad, 343
- American toads, 173-174
- ammocetes, 256-257
- amplexus, frogs, 264-266
- amphibians & reptiles of N. Y., Distribution, 170-172
- amphibians, Arabia, 196-202
- pleistocene, 96-102
- anaesthesia
- opaleye, 279
- lampreys, 164-165
- anal fin-rays, 32, 126, 145
- angler fish, 226
- Ancyllosetta, 140, 144
- anesthesia and recovery time of lampreys, dosage, 164-165
- Aniliidae, 39, 41, 44, 46
- anostomin characid fishes, 148
- Apoda, 38
- apodal fishes, 293
- Arabia, 196-202
- amphibians, 196-202
- aquaria, methods, 240
- reptiles, 196-202
- Arctic char, 345
- Ascension Island, herpetofauna, 69-70
- Atlantic loggerhead sea turtles, 257-259
- Atlantic sea herring, blood group system, 228-232
- Australia, 46, 51, 207-208, 266-270
- frogs, call structure, 266-270
- skink, 207-208
- banded darter, 342
- barracudina, 284
- bass, white, 77
- bathypelagic fish, 284-288
- behavior,
 - frog, 341
 - Gymnothorax*, 133
 - mudpuppy, 339-340
 - Plethodon*, 72-73
 - salmon, 76
- bibliography, coral snakes, 192-196
- birth, blue spiny lizard, 260-261
- blackchin shiner, 119
- black crappie, 77
- black marlin, 000
- blenny, scaleless, 276
- blenny, rockpool, 281
- blood group system, Atlantic sea herring, 228-232
- blood protein, frog, 176-178
- blood-squirting, horned lizard, 176
- bluebreast darter, spawning behavior, 240-243
- blue catfish, 342
- bluegill, 11, 16
- blue marlin, 347
- blue spiny lizard, 260-261
- boar fish, 343
- bodian's protargol silver, 138
- Boidae, 41, 43
- brackish water, frogs, 315-321
- broods, *Storeria*, 261-263
- brown moray, *Gymnothorax*, 133
- butterfly fish, Mississippi Sound, 252
- California, 172
- call, amphibian, 341
- Bombina*, 322-327
- effect of temperature on frog, 322-327
- races, tree frog, 327-385
- response of female frog to male, 341
- chorus frogs, 218-220
- structure, Australian frogs, 266-270
- variation, 322-327
- Callionymidae, meristics, 26
- Canada, 52
- capillaries, 91-96
- care of the eggs, lizards, 104, 106
- catfishes, neotropical, 276
- catfish, loracariid, teeth, 276
- catostomid fry, 157
- caudal fin, Anostomin characid fishes, 148
- Caudata, 38
- Centrarchidae, 298
- Ceylon, 47
- Chaetodon, meristics, 158
- characid, 148
- Chesapeake Bay, cub sharks, 251-252
- chorus frogs, 216-220
- clines, *Tarletonbeania*, 1-7
- Clupeidae, 298
- clupeid fishes, 134
- Columbia, 208-210
- coloration,
 - Draconetta*, 127, 129-130
 - gecko, 70
 - flatfish, 145
 - glossy water snake, 303-311
 - gobioid fish, *Eviotops*, 239
 - inheritance of in salamander, 33-37
 - Kaupichthys*, 293
 - Labrisomus*, 289-292
 - lampreys, 163
 - Lestidium*, 239, 286
 - Notropis, 9-10, 119
 - snipefish, 160
 - Parahollardia schmidtii*, 224
 - Paralepididae, 284-288
 - Sartor*, 150-151
 - skink, 207
 - Synaptolaemus*, 151
 - skinks, 118
- Colubridae, 40, 44, 48
- combat, 123-129
- commensals, echeneid fishes, 247
- common sturgeon, 77
- Coquette, 139, 143
- coral snakes, bibliography & index, 192-196
- corium tissue, 138
- corpuscles, Meissner's, 138
- cranial anatomy, pomacentrid, 152
- crappie, black, 77
- crappie, white, 77
- Crawford, 233
- crustacea, 300

- cub sharks, Chesapeake Bay, 251-252
 cyprinid, distribution, 7-10, 119-123
 cyclopean, Pomacentrid, 155
- dace, longnose, 160-162
 darter, 18-24, 242, 341
 Dasypeltinae, 68
 death: by starvation, fish, 344
 demonstration, erythrocyte antigen C, 229
 Delaware, 30, 31, 33, 74
 dentition—Labrisomus, 289
 description,
 Ancylopetta, 140-145
 Draconetta, 129
 gobioid fish, 237-240
 Kaupichthys diodontus, 293
 Kaupichthys japonicus, 293
 Labrisomus (*Gobioclinus*) *filamentous*, 289
 Lestidium, 284
 Parahollardia, 223
 diagnosis,
 Draconetta acanthopoma, 127
 Ancylopetta, 140, 143
 Draconetta xenica, 127
 glossy water snake, 303-311
 Notropis, 7
 diamond back terrapin, 257
 Diceratiidae, 225
 diet, echeneid fishes, 244
 threadfin shad, 298-302
 differentiation, *Ancylopetta* from *Gastropsetta*,
 146-147
 digestive organs, turtles, 337-339
 dimorphism sexual, *Draconetta*, 126
 dinoflagellates, 299
 distribution,
 amphibians and reptiles of New York, 170-
 172
 Ancylopetta, 147
 bigfin eelpouts, 75
 chorus frogs, 216-217
 cyprinid, 119-123
 fish, 284, 293
 Gastropsetta, 147
 glossy water snake, 303-311
 hellbender, 178-179
 Lichanura, 172
 Notropis, 121
 skink, 110-112
 snakes, 38-51
 turtles, 167-169
 yucca night lizard, 173
 dogfish, 276
 dorsal pattern, lizard, 261
 Draconettidae, 123-132
- early larval stages, red hake, 248-250
 ecology, 293
 Florida fishes, 77
 Notropis, 10
 frogs, 315-321
 Gymnothorax, 133
 eel, a new, 293
 egg-eating snake, 68-69
 eggs,
 frogs, 264-266, 315-321
 mudpuppy, 339-340
 mud snake, 71
 salmonids, 80
 scarlet snake, 263
 tree frog, 330
 Elapidae, 44, 48-50
- elasmobranchs, 278
 electric ray, 74
 enamel organs, 277
 eosin hematoxylin, 138
 erythrocyte antigen C, 229
 European newts, 91-96
 exogastrulation, tree frog, 327-335
- fall line, relation to distribution of turtles, 167-
 169
 fecundity, char, 345
 darters, 18-24
 feeding,
 behavior, rosy boa, 336
 spotted morays, 134-136
 turtles, 337-339
 fertilization,
 fish, 80
 tree frog, 327-335
 field observations of spawning, darter, 242
 fin-ray counts,
 Ancylopetta, 145
 Gastropsetta, 145
 fish,
 albinism, 253
 anaesthesia, 279
 bathypelagic, 284-288
 fauna, Minnesota, 341
 lion, 158
 luminous glands, 288
 parrot, 138
 zoarcid, 78-80
 flatfishes, 139-148, 253
 flight, lizard, 259-260
 Florida, 77-78, 96, 102, 110-119
 food,
 Coluber, 210-214
 glossy water snake, 303-311
 Rhinichthys, 162
 snakes, seasonal variation, 211-213
 fork lengths, shad, 291
 fossil turtles, morphology, 101
 four-spotted flounder, 253
 frog,
 amplexus, 264-266
 blood protein, 176-178
 Colombia, 208-210
 eggs, 264-266, 315-321
 hemoglobin, 176-178
 morphology, 208-210
 mineral chemistry, 176-178
 oviposition, 264-265
 red leg disease, 176-178
 fyke net, 11
- garter snakes, 52-56
 genetic incompatibility, tree frog, 327-335
 genetics, salamander, 33-37
 geographic variation, *Tarletonbeania*, 1-7
 geographic variation in occurrence of antigen C,
 230
 Georgia, 215-222
 gilt darter, 342
 Girellidae, 275
 gizzard shad, 300
 glands, luminous, fish, 288
 glossy water snake, 303-311
 gobioid fish, 237-240
 gravel chub, 342
 Great Basin gopher snake, 336
 greenside darter, 343
 grooming, lizards, 106-108

- growth,
 centrarchid, 13
 frogs, 63-68
 glossy water snake, 303-311
 rate, *Rhinichthys*, 161
- habitat,
 Kaupichthys, 295
 lizardfish, 234
hagfish, slime production, 165-166
hatching, lizards, 106
hawksbill, 257
hellbender, 178-179
hematoxylin, eosin, 138
hemoglobin, frog, 176-178
herpetofauna, Ascension Island, 69-70
holotype,
 Ancylorsetta cycloidea, 141
 Ancylorsetta kumperae, 144
 Lestidium johnnitchi, 284-288
 Parahollardia schmidtii, 224
 Sartor respectus, 149
horned lizard, blood-squirting, 176
hybrid crosses,
 A. jeffersonianum, 171
 races of tree frog, 327-335
hybrids,
 fish, 2, 81
 intergeneric, atherinid, 80
Hylidae, 312
hydrogen-ion concentration, turtles, 337-339
Hydrophiidae, 49
- Ichthyofauna, Lower Rio Grande, Tex., 253-257
illicium, 225, 227
Illinois, 178-179
index to the coral snakes, 192-196
India, 47
individual variation, glossy water snake, 303-314
inheritance, salamander, 33-37
integument, amphibians, 311-314
 reptiles, 311-314
intergeneric, hybrids atherinid, 80
intergradation, glossy water snake, 303-311
internal clock, fish, 16
isolating mechanisms, chorus frogs, 218-220
isthmus, 149
Istiophoridae, 349
- Japan, 293
jaw, 11
jaw tooth structure, comparisons of, 280
- keel, *Ancylorsetta*, 147
- Key,
 Ancylorsetta, 147-148
 Gastropsetta, 147-148
 lizardfish, 235-236
 Natrix rigida, 303-311
 species of *Draconetta*, 126
kymograph, 134
Kyphosidae, teeth, 281
- Labrisomini fish, 289
lampreys,
 coloration, 163
 larval activities, 256-257
 morphology, 163
largemouth bass, multiple recapture, 14
larval lampreys, 256-257
larval silver mullet, 252-253
lateral-line canal, spotted moray, 137
- leatherback, 257
lectotype, *Notropis*, 120, 121
Leptodactylidae, 313
Leptotyphlopidae, 39-43, 47, 51
lion fish, venom, 158-160
litter sizes, blue spiny lizard, 260-261
lion fish, 158
lizard,
 care of the eggs, 104-106
 dorsal pattern, 261
 flight, 259-260
 hatching, 106
 maternal behavior, 103-109
 morphology, 259-260
 sex discrimination, 103-109
lizard-fishes, 232-236
loggerhead, 257-259
longevity, snakes, 336-337
longnose dace, 160-162
lower Rio Grande, Tex., Ichthyofauna, 253-257
luminous glands,
 fish, 288
 myctophid, 1-7
lung capillaries, 91-96
- madtom, slender, 342
marking, 13, 14
marlin, 347
maternal behavior, lizard, 103-109
mating, mole snake, 71-72
Meissner's corpuscles, 138
melanophores,
 amphibians and reptiles, 311-314
 cyprinid, 10, 119
meristics,
 Ancylorsetta, 140
 angler fish, 226
 Chaetodon, 158
 characid fishes, 150
 garter snakes, 55
 Kaupichthys, 293
 Labrisomus (*Gobioclinus*) *filamentosus*, 289-292
 Lestidium, 284-288
 lizardfish, 234-235
 marlin, 347
 Paroneirodes, 227
 Parahollardia schmidtii, 223
 Paralepididae, 284-288
 Tarletonbeania, 2-6
metamorphosis,
 tree frog, 327
 lizardfish, 234
methods, aquaria, 240
Mexico, 57, 23-206
Microhylidae, 313
mineral chemistry, frog, 176-178
Minnesota fish fauna, 341
Minnesota toads, 173-174
Mississippi Sound, butterfly fish, 252
Mississippi threadfin shad, 298-302
mole snake, 71-72
moray, 134, 138
morphology,
 adult pomacentrid skull, 152
 Ancylorsetta, 140, 143
 angler fish, 226
 Aprodon, 75
 catostomid fry, 157
 chorus frogs, 217-222
 Cypselurus heterurus, 167
 Cypselurus luetkeni, 167
 cyprinid, 157

- Draconetta*, 127
 electric ray, 74
Entomacrodops macropus, 291
Eviotops storthynx, 238
 fossil turtles, 101
 frogs, 63-68, 208-210
 frog embryos, 315-321
 glossy water snake, 303-311
Hemidactylus, 198-199
Kaupichthys, 293-297
Labrisomus, 289-292
Lacerta, 335-336
 lampreys, 163
 lizard, 40, 259-260
 lungs, newts, 93
 marlin, 347
 newts, 93
Notropis, 9-10, 121
Parahollandia schmidtii, 223
 Paralepididae, 284-288
 pomacentrid, 153
 salamanders, 203-206
Sartor respectus, 150
 shark, 251
 skin, newts, 91-92
 skink, 207-208
 snake, 38-51
Storeria, 261-263
Trachydactylus, 199-202
 mortality, tree frogs, 327-335
 mouth, newts, morphology, 93
 movements, centrarchid, 11-18
 movements, turtles, 174-176
 mucous envelopes, 138
 mudsnake, 71
 mullet, larval silver, 252-253
 mullets, Pacific, 276
 multiple recapture-largemouth bass, 14
 myctophid fish, 1-7

 nematodes, 300
 neotropical catfishes, 276
 nesting habits, mudpuppy, 339-340
 net, stake gill, 27
 newts, European, 91-96
 New York, 170-172
 nidamental, eggs, 74
 normal sibling, *Pomacentrid cyclopean*, 155
 North America, 46
 northern pearl dace, 342
 North Pacific, 1-7
 nostrils, turtles, 257-259
 nuptial tubercles, cyprinid, 120
 ontogenetic characters, salamanders, 60-63

 opaleye, 275-283
 orangespotted sunfish, 77
 Oregon, 124, 132, 139, 143, 152, 233-234
 organs,
 enamel, 277
 luminous, 288
 ozark minnow, 342
 oviposition, frogs, 264-265
 orientation, turtles, 174-176

 Pacific moray, *Gymnothorax*, 136
 Pacific mullets, 276
 paralepidid fish, 284-288
 paralichthine flatfishes, 139
 parental care, fish, 19, 22-23
 parrot fishes, 138
 pattern,
 glossy water snake, 303-311
 skinks, 118
 Storeria dekayi, 262
 perch, yellow, 77, 78
 peritoneum, 121, 314
 peritoneum, pigmentation of, 314
 Petersen-type population estimates, 11, 17, 18
 pharyngeal teeth, cyprinid, 119, 121
 photophores, myctophid, 1-7
 phylogeny, snakes, 38-51
 physiography, pleistocene, 112-113
 physiology, newts, 91-96
 pigmentation, amphibians, 311-314
 pigmentation, reptiles, 311-314
 plains shiner, 342
 pleistocene amphibians & reptiles, 96, 102
 pleistocene physiography, 112-113
 plethodontid salamanders, 203-206
 pomacentrid, cranial anatomy, 152
 pomacentrid fish, 280
 pomacentrid, gross morphology of specimens, 153
 population estimates, Petersen, 11, 17, 18
 postlarvae, lizard fishes, 232-236
 predators, echeneid fishes, 247
 prickly sculpin, 156-158
 primary teeth, fish, 280
 progenic serial, teeth replacement, 282
 protargol silver, Bodian's, 138
 Protozoa, 300
 pseudoxenica, diagnosis, 126
 pugnose minnow, 342
 pugnose shiner, 119-123
 pumpkinseed, 11, 16
 pygmy whitefish, 342
 Pygopodidae, 38

 racer, *Coluber*, foods, 210-214
 rainbow darter, 342
 range, *Draconetta*, 127
 Ranidae, 312
 ratsnake, 68-69
 recapture, fish, 13-15
 redfin shiner, 342
 red hake, early larval stages, 248-250
 red leg disease, frog, 176-178
 red shiner, 342
 redside dace, 342
 reduction of the digits, skink, 113-114
 relationship,
 Ancylosetta, 142-143, 145-146
 Draconetta, 127, 124-126
 Eviotops, 239
 frogs, 215-222
 Labrisomus, 289-292
 Lestidium, 286-287
 Notropis, 10
 snakes, 38-51
 relative abundance, turtles, 167-169
 replacement teeth, 275-283
 reproduction, glossy water snake, 302-311
 reproductive cycle, swamp chorus frog, 263-266
 reptiles & amphibians of N. Y., distribution, 170-172
 reptiles, Arabia, 196-202
 reptiles, pleistocene, 96, 102
 respiration, newts, 91-96
 rosy boa, 336
 rotifers, 300

 salamanders,
 Mexico, 203-206
 morphology, 203-206
 Phethodontid, 203-206

- Salientia, 38, 92
 salinity,
 Chesapeake Bay, 251
 Mississippi Sound, 252
 North Pacific, 6
 tolerance, frog, 315-321
 salmonidae, 345
 salmonids, eggs, 80
 sand skink, 110-119
 Sauria, 39
 scaleless blenny, 276
 scarlet snake, young, 263
 Schmidt, Karl Patterson, 189
 schooling behavior, prickly sculpin, 156-158
 sculpin, Aleutian, 158
 sculpin, spoonhead, 342
 scutellation, glossy water snake, 303-311
 sea lamprey, 256-257, 342
 seasonal variation, food of snakes, 211-213
 seasonal variation in fish movement, 25-26
 sea turtles, Atlantic loggerhead, 257-259
 sensory physiology, morays, 135-138
 serpentes, 38-51
 serum, 176-178, 229
 sex discrimination, lizards, 103-109
 sex ratios, *Rhinichthys cataractae*, 161-162
 sexual dimorphism, *Draconetta*, 126, 127, 129
 sexual maturity, skinks, 117
 shad, stomach analysis, 298-300
 shad, threadfin, Mississippi, 298
 sharks, morphometry, 251, 276
 shiner, blackchin, 119
 shiner, pugnose, 119-123
 shiner, Topeka, 120
 shortnosed sturgeon, 77
 sight, moray, 138
 size, skinks, 117
 skin capillaries, 91-96
 skink,
 Australian, 207-208
 coloration, 118, 207
 distribution, 110-112
 morphology, 207-208
 pattern, 118
 sand, 110-119
 sexual maturity, 117
 variation, 117-118
 skin, vascularization, 92
 skygazer shiner, 7-10
 slenderhead darter, 342
 slender madtom, 342
 slime production, hagfish, 165-166
 smell, 138
 snake, Great Basin gopher, 336
 snakes, longevity, 336-337
 snakes, relationship, 38-51
 snake, Trans-Pecos rat, 336
 snipefish, 160
 sockeye salmon, 345
 soft rays, anal fin, 126
 South Africa, 71-72
 South American, 46
 spawning behavior, bluebreast darter, 240-243
 spawning tray, 240
 speciation, tree frog, 327-335
 speckled chub, 342
 spoonhead sculpin, 342
 spotted cusk eel, 343
 spotted gar, 343
 spotted moray, 133
 Squamata, 43
 Squalidae, 30
 stations, Albatross, 78
 stomach analysis, shad, 300
 sturgeon, common, 77
 striped marlin, 347
 striped mullet, 252
 sturgeon, shortnosed, 77
 suckermouth minnow, 342
 sunfish, orangespotted, 77
 survival, tree frog, 327-335
 swamp chorus frog, reproductive cycle, 263-266
 symbionts, echeneid fishes, 247
 sympatry, *Tarletonbeania*, 4
 Synodontidae, 236
 synonym, frog, 340
 syntypes *Notropis*, 120-121
 tadpole, collecting method, 72-73
 tags, 28, 30
 taste bud, spotted moray, 137
 teeth,
 clipping, opaleye, 279
 Parahollardia schmidtii, 223
 pharyngeal cyprinid, 119, 121
 replacement, progenic polyphyodont, 282
 replacement, progenic serial, 282
 shark, 276
 shedding, opaleye, 276
 temperature, effect of on call of frog, 322-327
 threadfin shad, 298-302
 toads, American, 173-174
 toads, Minnesota, 173-174
 tooth attachment, opaleye, 376
 tooth replacement, blennioid fish, 275-283
 tooth structure, primary, opaleye, 276
 Topeka shiner, 120
 touch, spotted moray, 138
 Trans-Pecos rat snake, 336
 tree frog, 327-335
 Triacanthodidae, 222
 tubercles, cyprinid, 10
 tubercles, nuptial, 120
 turtles,
 digestive organs, 337-339
 hydrogen-ion concentration, 337-339
 morphology, fossil, 101
 movements, 174-176
 nostrils, 257-259
 orientation, 174-176
 relative abundance, 167-169
 Typhlopidae, 39-43, 47, 51
 ultraviolet light, transmission of,
 in amphibians and reptiles, 311-314
 uterus, electric ray, 74
 urohyal bone, 146
 Uropeleidae, 41-44, 46
 variation,
 calls of frogs, 327-335
 frogs, 63-68
 glossy water snake, 303-311
 skinks, 117-118
 Tarletonbeania, 1-7
 vascularization, 93
 venom, lion fish, 158-160
 venom, snake, 73-74
 vertebrae, caudal, fish, 125, 126
 vertebral centra, myctophid, 1-7
 vertebral counts, cyprinids, 8
 Viperidae, 44, 50

warmouth, 342
weights, shad, 299
white bass, 77
white crappie, 77
whitefish, pygmy, 342
Wisconsin, 11
Wyoming, 63-68

Xenocongridae, 293

Xenoderminae, 48
Xenopeltidae, 41, 43-44, 46

yellow perch, 77, 78
young, scarlet snake, 263

zebraperch, teeth, 281

Zoarcidae, 78

zoarcid fishes, taxonomy & distribution, 78-80

zootoxicology, 73-74

He
Pr
Pr
Va

Tr
Se
Pr
Ed

Ed

Pr
Va
Se

Pr
Va
Se

J.

tut
cil
tri

Bas
Sub
Du
Lif
Pat
All
Du
Me
Ma
Ma

Ori
Rep
Fig

COPEIA IS THE JOURNAL OF THE AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS

Officers

Honorary President—HELEN T. GAIGE, 1211 Ferdon Road, Ann Arbor, Michigan.

President—REEVE M. BAILEY, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

President-Elect—NORMAN E. HARTWEG, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

Vice-Presidents—(Conservation) M. GRAHAM NETTING, Carnegie Museum, Pittsburgh 13, Pennsylvania; (Finance) JOHN C. BRIGGS, Dept. of Anatomy, University of British Columbia, Vancouver 8, British Columbia; and (Membership) JAMES KEZER, Dept. of Biology, University of Oregon, Eugene, Oregon.

Treasurer—JAMES E. BÖHLKE, Academy of Natural Sciences, 19th and Parkway, Philadelphia 3, Pennsylvania.

Secretary—ROGER CONANT, Philadelphia Zoological Garden, 34th Street and Girard Avenue, Philadelphia 4, Pennsylvania.

Publications Secretary—N. BAYARD GREEN, Biology Dept., Marshall College, Huntington 1, West Virginia.

Editors—Editor-in-Chief, PHILIP W. SMITH, State Natural History Survey Division, Urbana, Illinois; Book Review Editor, ERNEST E. WILLIAMS, Biological Laboratory, Harvard University, Cambridge, Massachusetts; and Index Editor, DAVID L. JAMESON, Dept. of Biology, San Diego State College, San Diego, California.

Editorial Board—Ichthyology: REEVE M. BAILEY, JAMES E. BÖHLKE, ROBERT W. HARRINGTON, JR., CLARK HUBBS, GILES W. MEAD, ROBERT R. MILLER, EDWARD M. NELSON, EDWARD C. RANEY, LIONEL A. WALFORD, LOREN P. WOODS. Herpetology: CHARLES M. BOGERT, EDWIN H. COLBERT, HENRY S. FITCH, WADE FOX, JR., HOWARD K. GLOYD, LAURENCE M. KLAUBER, JAMES A. OLIVER, CLIFFORD H. POPE, WILLIAM H. STICKEL, JOSEPH A. TIHEN.

Officers of Western Division

President—EARL S. HERALD, California Academy of Sciences, San Francisco, California.

Vice-President—JAMES KEZER, University of Oregon, Eugene, Oregon.

Secretary-Treasurer—LILLIAN DEMPSTER, California Academy of Sciences, San Francisco, California.

Officers of Southeastern Division

President—JOSEPH R. BAILEY, Dept. of Zoology, Duke University, Durham, North Carolina.

Vice-President—ELMER E. BROWN, Dept. of Biology, Davidson College, Davidson, North Carolina.

Secretary-Treasurer—WILLIAM J. RIEMER, Florida State Museum and University of Florida, Gainesville, Florida.

Honorary Foreign Members

J. C. BATTERSBY; L. F. DE BEAUFORT; L. D. BRONGERSMA; FERNANDO DE BUEN; J. GUIBÉ; WALTER HELLMICH; CURT KOSSWIG; C. C. LIU; NICÉFORO MARIA; N. B. MARSHALL; KIYOMATSU MATSUBARA; ROBERT MERTENS; H. W. PARKER; H. RENDAHL; GUISEPPE SCORTECCI; J. L. B. SMITH; A. N. SVETOVIDOV; ETHELWYNN TREWAVAS; DAVID M. S. WATSON; G. F. DE WITTE.

Affiliations

The American Society of Ichthyologists and Herpetologists is a member of the American Institute of Biological Sciences and of the Division of Biology and Agriculture, National Research Council, and is an affiliate of the American Association for the Advancement of Science. An annual contribution is made to the publication of the Zoological Record.

Back numbers of COPEIA, as available, may be procured from Prof. N. B. Green, Biology Dept., Marshall College, Huntington, West Virginia. Prices will be furnished on application.

Subscription, \$9.00 per annum, \$2.50 a copy.

Dues to Society: foreign and student members \$6.00 annually; regular members \$8.00 annually; sustaining members \$25.00 annually.

Life membership: \$150.00 single payment (may be purchased in annual installments of \$25.00 each).

Patrons: \$1000.00 single payment.

All memberships include subscription to COPEIA.

Dues and subscriptions are payable to the Society, through the Secretary.

Members should notify the Secretary immediately of any changes in address.

Manuscripts, news items, and all correspondence regarding the Journal should be addressed to the Editor.

Manuscripts should be submitted on good paper, as original typewritten copy, double-spaced, carefully corrected.

Galley proof will be furnished authors.

Original contributions from members of the Society, not to be published elsewhere, are alone acceptable.

Reprints are furnished at approximate cost.

Figures, author's corrections, expensive tabular matter and unusually long articles may be charged in whole or in part to the author at the discretion of the Editor.



C37

0585
132E
25E3
33E6
42E9
55E2
6E99



0585
132E
25E3
33E6
42E9
55E2
6E99

0585
132E
25E3
33E6
42E9
55E2
6E99



0585
132E
25E3
33E6
42E9
55E2
6E99